The Economic Benefits of the New Jersey Stem Cell Research Initiative

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Executive Summary

This report estimates the potential economic benefits to New Jersey of the proposed stem cell research initiative. New Jersey has a long history of innovation and discovery leading to sustained and profound improvements in the quality of life and accompanying threshold increases in income, jobs, and economic activity. The proposed stem cell initiative is consistent with this legacy and offers the state the opportunity to be a full participant in the collaborative worldwide research effort that has such promise to alleviate the pain and suffering of so many.

We estimate the potential economic benefits of the initiative for six areas.

- **<u>Benefits Directly Attributable to the Initiative.</u>** We estimate that the economic benefits to New Jersey that can be attributed directly to the initiative - - the economic impact of expenditures, the retention and expansion of the biotechnology industry, and the royalty payments from intellectual property - - are $1.4 billion in new economic activity, close to 20,000 new jobs, and $71.9 million in new state revenues (taxes and royalties) over the time period 2006 to 2025. (See p. 43 and Table 19, p. 46).

    - **<u>Economic Impact of Public Expenditures.</u>** From 2006 to 2008, the $150 million in proposed capital and equipment expenditures will create over 1,450 jobs, generate $118.2 million in additional economic activity, and increase state tax revenues by $3.6 million and local tax revenues by $4.1 million. (See pp. 4-6). In addition, from 2006 to 2013, the $230 million in proposed research spending will create almost 2,600 jobs, generate $217.6 million in economic activity, and increase state tax revenues by $6.7 million and local tax revenues by $7.4 million. (See pp. 7-8).

    - **<u>Retention and Expansion of Biotechnology and Pharmaceutical Industries.</u>** There is a large and vibrant biotechnology industry in New Jersey that is subject to intense global competition. Public policies that create a supportive environment for stem cell research, including state of the art research capacity and the attraction of excellent scientists and students at Rutgers and UMDNJ and other New Jersey higher education institutions, will be an important factor in retaining and expanding this industry. Using conservative assumptions about the amount of private leveraging of public investment, we estimate that close to 16,000 additional jobs will be created, and economic activity in the state will expand by over $1 billion in the 2006 to 2025 period. This additional activity will also generate $40.3 million in additional state tax revenues and $44.4 million in new local tax revenues. (See pp. 32-40).

- **Royalty Payments to New Jersey.** New intellectual property that potentially can be generated from the state's investment in stem cell research is estimated to result in $21.3 million in royalty income for New Jersey in the period 2016 to 2023. This estimate is based on a conservative assumption about the total investment costs historically required for a successful commercial therapy. (See pp. 40-42).

- **Broader Benefits to New Jersey.** A broader aggregation of potential stem cell therapy benefits to New Jersey consisting of reductions in health care costs, savings in work time lost, and decreases in premature deaths will occur independent of the location of the research that develops those therapies. Over the period 2016 through 2025, such benefits total close to $73 billion, using conservative assumptions about the efficacy of the therapies. State fiscal gains from both types of benefits - - those directly attributable to the initiative and those that accrue to New Jersey regardless of where the research is done - - are estimated to be $1.9 billion. (See p. 43-45 and Table 20, p. 46).

- **<u>Savings in Health Care Costs.</u>** We analyze six health conditions (diabetes, Parkinson's Disease, spinal cord injury, heart attack, stroke, and Alzheimer's Disease) that are likely to benefit from stem cell therapies. An estimated 363,000 New Jerseyans currently suffer from these conditions. We estimate that health care costs in New Jersey will be reduced by $11.3 billion over the ten year period from 2016 to 2025 as a result of the implementation of effective stem cell therapies. This total includes a $1.7 billion savings to the state budget. (See pp. 9-18).

- **<u>Work Time and Economic Productivity Savings.</u>** We estimate that, in the absence of improved treatments, over 10.5 million workdays in New Jersey will be lost because of these six health conditions from 2016 to 2025. Using conservative assumptions about the effectiveness of stem cell therapies, we estimate that there will be a savings of $813 million to the New Jersey economy from reductions in work days lost. (See pp. 18-21).

- **<u>Value of Premature Deaths Avoided.</u>** The core goal of stem cell research is to alleviate the human suffering and pain associated with disease and injuries. Accordingly, a central benefit of the research will be the reduction in premature deaths as a result of new therapies. We estimate that, in the absence of new treatments, close to 75,000 New Jerseyans will die prematurely (losing a total of 818,000 life-years) from the six health conditions during the period 2016-2025. Again, using conservative assumptions about the effectiveness of potential stem cell therapies, as well as for the value of a life-year saved, we estimate benefits of over $60.7 billion in New Jersey due to reductions in premature deaths. (See pp. 21-30).

- **Caveats.** While we have consistently used conservative assumptions throughout the report, it is important to note 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 understand that we do ***not*** attribute all the benefits estimated in the report to New Jersey's investment in stem cell research. Specifically, the benefits from premature deaths avoided, the benefits of the reduction in work days lost due to illness, and the health care 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.

Introduction

This report provides a preliminary analysis of the potential economic benefits of New Jersey's proposed stem cell initiative. There is enormous promise in stem cell research to improve the quality of human life as a result of the possible reduction in the costly effects of a number of particularly devastating diseases - - stroke, heart attack, diabetes, Parkinson's Disease, spinal cord injury, and Alzheimer's Disease. However, the potential for unanticipated breakthroughs in many other areas of human health is unlimited and any estimates of the impact of stem cell research on future health conditions must be regarded as educated projections subject to wide variation and uncertainty.

Basic research, without specific initial purpose, has often been the source of powerful and ubiquitous impacts on society. Such research has, at times, resulted in the development of vast new industries and accompanying threshold increases in income, employment, and economic activity with profound improvements in the quality of life. Antibiotics, the laser, the computer chip, and the Internet are examples of the often-unpredictable outcomes that have emerged from basic research. Basic research has led to major innovations that have transformed how we live and how well we live in unexpected and comprehensive ways.

The six areas of economic benefits of New Jersey's stem cell initiative identified in this report are: the direct economic impact of significant state expenditures on buildings, equipment and research grants; the potential reduction in overall health care costs and in New Jersey State budget health care costs associated with new stem cell therapies; the savings in work time and economic productivity now lost due to health conditions that potentially can be ameliorated by stem cell therapies, the public good benefits of reductions in premature deaths; the attraction, retention and expansion of the biotechnology and pharmaceutical industries in New Jersey, and the royalty payments to the state as an investing partner in stem cell research.

There is ample documentation of the potential impact of the efforts currently underway in a number of states to develop research capacity in human embryonic stem cells. However, it is important to stress that this report is necessarily a quick and preliminary analysis. The importance and complexity of stem cell research to the future of New Jersey and the broader potential effects on the nation and world merit a full and deliberate analysis that is beyond the scope of this preliminary report.[1]

Economic Impact of Public Expenditures

The New Jersey stem cell initiative calls for an initial investment of $100 million in a new research facility to be managed jointly by Rutgers University and the University of Medicine and Dentistry of New Jersey, $50 million in associated equipment and technology for the facility, and $230 million in peer-reviewed research grants to support stem cell research. New expenditures of this magnitude will directly create jobs and increase economic activity. These activities will, in turn, have complex and interrelated effects on other business sectors of the New Jersey economy. Such effects will be distributed over the other sectors depending on the type of expenditures (construction, equipment, salary, supplies, etc.) and on the specific economic interconnections of the type of expenditure both within and outside of the New Jersey economy.

Economists have long studied the linkages among sectors of the economy and have estimated the effects of a single event (e.g., a plant closing, a business relocation, a new facility, a reduction in taxes, etc.) on changes in economic activity using the tool of input-output analysis. This technique estimates the relationships among sectors in terms

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[1] This report draws heavily upon the work done for California. See, Economic Impact Analysis, Proposition 71, California Stem Cell Research and Cures Initiative, Lawrence Baker and Bruce Deal, Analysis Group, Inc., September 14, 2004, pp. 1-97.

of production and consumption for any initial change in economic activity in one sector or group of sectors. The empirical linkages are derived from sustained observations of the actual economic interrelationships in the economy and then expressed in a model that enables the estimation of the effects of changes in economic activity on output, employment, income, gross state product, and tax revenues.

The Edward J. Bloustein School of Planning and Public Policy at Rutgers University has the scholarly capability in its Center for Urban Policy Research to perform such analyses using one of the most advanced and sophisticated input-output tools available, namely, the R/ECON regional economic model. This model contains over 500 sectors and captures the myriad associated linkages among these sectors and the resulting economic multipliers that enable the estimation of the total economic effects of a specific project or economic event.

Using this model, the economic impact of the stem cell initiative expenditures can be estimated. There are three components of these expenditures. First, a new $100 million research facility jointly managed by Rutgers University and the University of Medicine and Dentistry of New Jersey, second, the associated expenditures of $50 million in related equipment and technology, and third, the award and subsequent expenditure of $230 million in peer-reviewed research grants to New Jersey-based researchers. These are one-time expenditures that will occur over a period of years. The $150 million for the construction and outfitting of the research facility is expected to be spent over a two-year period commencing in state fiscal year 2006. The $230 million for research grants is expected to be spent over a seven-year period beginning in state fiscal year 2006.[2]

[2] We do not examine whether the expenditure of these same resources for other private or public purposes would generate different economic outcomes. Also we do not examine the complex efficiency and equity effects on the economy that would occur depending on the method of financing of these expenditures (taxes, borrowing, or reductions in other public expenditures).

Table 1 provides an estimate of the effects of the construction of a $100 million research facility on employment, income (personal earnings), gross state product, and tax revenues (federal, state, and local). These effects are divided into *direct effects* of spending $100 million for construction and the *indirect effects* (the induced effects of these expenditures on other industries). The top panel in Table 1 gives the size and the distribution of the economic effects. The economic impact of the $100 million is significant - - 1,069 additional jobs are directly and indirectly created due to the economic linkages between the construction industries and their supporting industries.[3] Gross State Product (GSP) in New Jersey (the total value of all newly produced goods and services) would increase by $75.5 million (in 2004 dollars). The increase in the state's GSP is the appropriate measure of the overall impact to the state's economy.[4] To this total should be added the additional taxes paid by households ($12.3 million) listed in the second panel of Table 1. These are the property, sales, income, and other taxes paid by households as a result of the overall increase in economic activity, directly and indirectly created.[5] Thus, the overall impact of the $100 million construction for the stem cell research facility on the New Jersey economy is $87.8 million (the increase in GSP plus household taxes paid) including $2.9 million in additional local tax revenues and $2.6 million in additional state tax revenue.

The economic impact of the expenditure of $50 million in equipment is listed in Table 2. A total of 393 job-years would be created, $25.7 million in added Gross State Product, and with additional household taxes paid ($4.6 million), there would be a positive impact of $30.3 million in New Jersey, including $1.18 million in new local tax revenue and $1.03 million in new state tax revenues.

[3] Technically, the expenditure of $100 million over a two-year construction period will generate 1,069 "job-years" of employment. For example, if $50 million is spent in year one of the project, that spending will create 534.5 jobs in year one, and then, the expenditure of the other $50 million in year two would create another 534.5 jobs in the second year, for a total of 1,069 "job-years."
[4] The GSP increase is more than the income (i.e., earnings) impact ($60.5M) because the income measure does not include various taxes paid by businesses.
[5] Taxes paid by businesses - - property, sales, state and federal corporate tax, and other taxes - - are included in the GSP measure. Taxes paid by households are not included in this measure and must be estimated by level of government and added to the business taxes paid to obtain overall tax revenues.

Table 1
Economic and Tax Impacts on New Jersey of Building a $100 Million Stem Cell Research Facility (2004 $)

ECONOMIC EFFECTS

	Employment (jobs)	Income (000$)	Gross State Product (000$)
Direct Effects	723	45,734.7	53,657.3
Indirect Effects	346	14,829.0	21,884.7
Total Effects	**1,069**	**60,563.7**	**75,542.0**

TAX REVENUES GENERATED[1]

	Total (000$)	Paid by Households (000$)
Local Taxes	2,870.2	1,575.2
State Taxes	2,580.9	1,379.1
Federal Taxes	17,364.8	9,334.6
Total Taxes	**22,815.8**	**12,288.9**

1. Business taxes paid equal total taxes minus household taxes paid.

Table 2

Economic and Tax Impacts on New Jersey of Purchasing $50 Million in Scientific Laboratory Equipment & Office Equipment (2004 $)

ECONOMIC EFFECTS

	Employment (jobs)	Income (000$)	Gross State Product (000$)
Direct Effects	240	15,828.9	15,918.1
Indirect Effects	153	6,970.9	9,798.7
Total Effects	**393**	**22,799.8**	**25,716.7**

TAX REVENUES GENERATED[1]

	Total (000$)	Paid by Households (000$)
Local Taxes	1,181.2	593.0
State Taxes	1,033.0	519.2
Federal Taxes	6,342.0	3,514.1
Total Taxes	**8,556.2**	**4,626.3**

1. Business taxes paid equal total taxes minus household taxes paid.

Table 3 provides estimates of the economic impact of the expenditure of $230 million in research grants. Again, it is important to note that these estimates refer only to the economic impact of expenditures and do not capture the ultimate potential health benefits of the research that these expenditures support, nor the possible leveraging of those research expenditures in attracting other research support from federal funding agencies, foundations, and the private sector. A preliminary estimate of the health benefits is presented subsequently in this report. Any leveraging of the research grants would have the same proportionate economic impact as the initial research expenditures. Thus, if the $230 million in research grants leads to, in time, an increased ability of New Jersey researchers to compete for federal, foundation, and private research support and does so on a 1 to 1 basis, then the economic impact would be twice that reported in Table 3.[6] Moreover, this increase in federal and foundation research funding, over and above what the State would receive in the absence of the stem cell initiative, would continue after the $230 million in state stem cell research support has been awarded and spent.

The economic impact of the $230 million in expenditures will occur over a projected seven-year period during which these expenditures are made. The employment impact of the $230 million in expenditures on research grants is considerable - - an estimated 2,599 job-years created. However, if the research project continues after the state research support ends, as is likely since additional support from diverse funding sources is typical research practice and the objective of researchers and their labs (particularly academic researchers), then additional job-years will be created depending on the length of the continuation of the work and the amount of additional research support received. Gross State Product increases by an estimated $184.1 million. With the inclusion of household taxes ($33.5 million), the total economic impact is $217.6 million, including $7.4 million in additional local tax revenues and $6.7 million in additional state taxes.

[6] However, the amount of such leveraging would depend on several factors, such as the level and changes in available federal funding (especially NIH funding) and the scientific content and promise of the research supported. Thus, there is considerable uncertainty as to how much leveraging will occur from the $230 million in state research support. Nevertheless, the estimates in Table 3 should be regarded as conservative. If all the leveraging of the state's investment comes from sources outside New Jersey, then there will be no additional costs to taxpayers.

Table 3
Economic and Tax Impacts on New Jersey of $230 Million in Stem Cell Research Grants (2004 $)

ECONOMIC EFFECTS

	Employment (jobs)	Income (000$)	Gross State Product (000$)
Direct Effects	1,670	124,544.0	124,561.9
Indirect Effects	929	40,361.4	59,537.5
Total Effects	**2,599**	**164,905.4**	**184,099.4**

TAX REVENUES GENERATED[1]

	Total (000$)	Paid by Households (000$)
Local Taxes	7,355.1	4,289.1
State Taxes	6,693.9	3,755.0
Federal Taxes	44,801.2	25,416.7
Total Taxes	**58,850.2**	**33,460.8**

1. Business taxes paid equal total taxes minus household taxes paid.

Table 4
Total Economic and Tax Impacts on New Jersey of a $380 Million Investment in Stem Cell Research (2004 $)

ECONOMIC EFFECTS

	Employment (jobs)	Income (000$)	Gross State Product (000$)
Direct Effects	2,633	186,107.6	194,137.2
Indirect Effects	1,428	62,161.3	91,220.9
Total Effects	**4,061**	**248,268.9**	**285,358.1**

TAX REVENUES GENERATED[1]

	Total (000$)	Paid by Households (000$)
Local Taxes	11,406.5	6,457.4
State Taxes	10,307.8	5,653.2
Federal Taxes	68,508.0	38,265.5
Total Taxes	**90,222.3**	**50,376.0**

1. Business taxes paid equal total taxes minus household taxes paid.

The combined economic impact of the expenditure of $380 million - - the $100 million for the stem cell research facility, $50 million for equipment, and $230 million for research grants - - is provided in Table 4. Over 4,000 job-years would be created and $335.7 million in economic activity ($285.4 million in additional Gross State Product and $50.4 million in taxes paid by households). Total local tax revenues would increase by $11.4 million and state tax revenues would rise by $10.3 million. These revenues would be received over the seven-year period of spending of the $380 million. As noted, these estimates do not include the economic impact of additional leveraged research grant support that may be received from federal, foundation, and private sources as a result of the increased capacity of New Jersey for stem cell research. Accordingly, these impacts should be regarded as conservative estimates of the economic effects of the spending of $380 million for stem cell research.

Savings in Health Care Costs

A major potential effect of stem cell research is the possible reduction in health care costs as a result of new therapies that cure certain devastating health conditions, reduce the severity of these conditions, or delay their onset. While the therapies themselves that result from stem cell research may be costly, the overall impact of decreasing the prevalence and the current treatment costs of a number of diseases is potentially extremely large.

It is useful to note here that the development of effective stem cell therapies anywhere in the country (or, indeed, elsewhere in the world) will, in time, affect health care costs in New Jersey. Our state, like other areas of the country, would eventually share in these reductions in health care costs and the improvement in health since profit opportunities in new therapies would provide the incentives for the therapies to be implemented on a comprehensive scale. New Jersey and its citizens would also pay for these therapies through the existing health care financing mechanisms. Thus, attribution of health care cost savings would be independent of the particular source and location of the research that led to the successful development and implementation of the therapies.

Assigning health care savings to the specific investments made by New Jersey would assume that there is a direct causality between the New Jersey stem cell research and specific therapies that are eventually implemented in national or global applications. While this may occur, the purpose of this section is to estimate the magnitude of what can be achieved by relatively small (percentage) reductions in total health care costs in New Jersey.

Thus, we begin with examining the current total health care cost of the six conditions previously discussed.[7] The first step in the analysis is to estimate the prevalence of these conditions (i.e., how many cases of these conditions exist in the population of New Jersey now, and over a future time period). We apply national prevalence rates for the six conditions to the New Jersey population in each age group in order to estimate the prevalence of each condition.[8] We also project the prevalence for each condition on an annual basis from 2016 to 2025 using New Jersey population estimates. We assume the implementation of effective stem cell therapies begins in the 11th year of the initiative, given the substantial time delays from the initiation of research to the actual widespread implementation of therapies.

Table 5 lists the prevalence rates for each condition by age group and the estimate of the number of individuals in New Jersey with each condition in 2004. These are estimates of the number of individuals in New Jersey that require some level of on-going health care treatment for these conditions. The prevalence rates range from a low of .1% for Parkinson's Disease in the 19-64 age group to a high of 6.35% for Alzheimer's Disease in the 65 and over age group. The condition with the largest number of cases is Acute Myocardial Infarction (117,608). A total of 362,759

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[7] Recall these six conditions are: stroke, heart attack, diabetes, Parkinson's Disease, spinal cord injury, and Alzheimer's disease. However, if stem cell therapies also result in the cure or amelioration of other health conditions, then the cost savings estimated here would understate, and probably by a large amount, the actual health care savings that could result from stem cell research.

[8] Sources for these prevalence rates are listed in Section A-1 of the Appendix. The prevalence rate for Alzheimer's Disease was increased 1.2% per year from the base period (Analysis Group, *op. cit.,* p. 63). We use the Analysis Group's age categories for the six conditions, but also add the over 65-age group for both Alzheimer's Disease and Parkinson's Disease. The Analysis Group does not estimate prevalence rates for heart attack and stroke in the over-65 age group.

Table 5
Estimated Prevalence Rates and Number of Sufferers
New Jersey, 2004

Disease/Condition	**Age Group**	**Prevalence Rate**	**Number of Sufferers**
Type 1 Diabetes	0-18	0.21%	4,778
	19-64	0.34%	18,013
LADA[1]	19-64	0.78%	41,322
Parkinson's Disease	19-64	0.10%	5,298
	65 and over	1.0%	11,261
Spinal Cord Injury	0-18	0.06%	1,365
	19-64	0.10%	5,298
Acute Myocardial Infarction	19-64	2.22%	117,608
Stroke	19-64	1.09%	57,744
Alzheimer's Disease	19-64	0.54%	28,607
	65 and over	6.35%	71,465
Total	**All**	**-**	**362,759**

1. Latent autoimmune diabetes in adults.

individuals in New Jersey are estimated to have (at least) one of these six health conditions in 2004.

The prevalence estimates for the New Jersey population by condition over the 2016 to 2025 time period are provided in Section A-2 of the Appendix. It is this population, and all future individuals with these health conditions after 2025, which will receive the benefits of stem cell therapies.

Estimating the costs of health care treatment in New Jersey for these conditions is a complex process. We focus on estimating *incremental costs*, that is, the costs that the average condition incurs in annual medical care *over and above* the annual health care costs of a person without this condition of similar profile (e.g., age).[9] These costs do not include the immediate costs that are incurred from the acute stages of the condition where appropriate.[10] The incremental health cost totals we estimate represent the total costs of all components of health care in New Jersey, i.e., the private costs incurred by individuals and families, the cost to insurers, state health care costs, and federal health care costs. The total annual average incremental health care costs by condition (in 2004 dollars) are listed in Table 6 and range from $4,500 for an individual with Parkinson's Disease to $122,334 for an individual with high tetraplegia spinal cord injury.[11]

The annual average incremental treatment costs from 2004 forward are increased 4.2% per year to reflect historical inflation in health care.[12] These annual incremental costs are multiplied by the estimated number of individuals suffering from each condition

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[9] Obviously, to estimate such costs for an "average sufferer" masks very large variations in costs and personal suffering across individuals. We recognize that such averages do not convey the frequently catastrophic costs and nature of these conditions for many of those who suffer from them.
[10] For example, the stroke or the spinal cord injury is still assumed to occur and has immediate and substantial treatment costs during this acute phase of the condition. We do not include such costs in the total incremental costs that may be subject to cost savings as a result of a stem cell therapy. More generally, we do not attempt to estimate how incremental costs may change in the future due to new, non-stem cell therapies, nor due to any future structural changes in the health care financing system.
[11] Injury to one or more of the upper four segments of the spinal cord.
[12] The inflation rate is based on a ten-year average of increases in the medical and medical service component of the Consumer Price Index. See, Analysis Group, *op. cit.,* p.66. Future inflation in health care is complex and we do not attempt to estimate changes in the mix or relative costs of different health care inputs over time.

Table 6
Annual Incremental Per-Patient Costs of Treatment
(in 2004 dollars)

Disease/Condition	**Age Group**	**Cost of Treatment**
Type 1 Diabetes and LADA	0-64	$9,744
Parkinson's Disease	19 and over	4,500
Spinal Cord Injury		
Incomplete Motor Function	0-64	14,106
Paraplegia	0-64	25,394
Low Tetraplegia	0-64	50,110
High Tetraplegia	0-64	122,334
Acute Myocardial Infarction	19-64	10,920
Stroke	19-64	7,269
Alzheimer's Disease[1]		
No nursing home care	19-64	5,909
Nursing home care (incremental)	65 and over	19,172
Nursing home care (total)	65 and over	73,360

1. For purposes of cost estimation, we assume that those in the 19-64 age group do not require nursing home care. Their costs include only the incremental costs of physician care and paid at-home care. For those in the 65 and over group, we estimate the costs in two ways. The "incremental cost" approach includes the aforementioned non-nursing home costs, and adds the cost of providing care to an Alzheimer's patient in a nursing home over and above the cost of treatment for a non-Alzheimer's sufferer in a nursing home. The "total costs" approach assumes that the Alzheimer's sufferer would not be in a nursing home were it not for the disease, and thus the full costs of nursing home care are included. Sources for the treatment cost estimates are given in Section A-3 of the Appendix.

(i.e., derived from New Jersey population projections and the prevalence estimates in Table 5). This provides estimates of the annual total incremental health care costs by condition. These annual costs by condition are aggregated over ten years (from 2016 to 2025), the period of time during which an effective stem cell therapy would be implemented given the estimate of the delay between research effort and the full implementation of a therapy.[13] The total estimated health care costs for New Jersey over the ten-year period are given in Table 7. In the aggregate, the ten-year cumulative cost for all six conditions is $113.4 billion using conservative assumptions.[14] The individual health condition components range from an estimated $1.9 billion for all sufferers of Parkinson's Disease to $47 billion for all sufferers of Alzheimer's Disease over 65 years of age.

The estimated total incremental health care costs are then reduced by the application of effective stem cell therapies. Effective stem cell therapies beginning in 2016 are estimated to reduce these health care costs by one percent, two percent, and ten percent reflecting assumptions of the efficacy of the therapies from modest to significant.[15] The amount of health care cost savings over the ten-year period is indicated in Table 8 and is large, ranging from $1.1 billion for a one percent reduction in health care costs to $11.3 billion for a 10 percent reduction. Accordingly, the analysis of Tables 7 and 8 indicates the extraordinarily large aggregate cost to society of treating the six health conditions examined in this report and the significant potential savings to New Jersey from reducing this total cost by relatively small percentages.

These same cost reduction scenarios are also applied to the New Jersey share of the total incremental health care costs. In 2000, the New Jersey State budget funded an

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[13] The ten-year period is limited by the population projections. Health care cost savings would continue after 2025 and thus our estimates understate future total savings.

[14] Specifically, we assume incremental nursing costs for Alzheimer's disease, i.e., the estimated nursing home costs are limited to only costs over and above the nursing home costs likely to be incurred in the appropriate age groups without Alzheimer's Disease.

[15] These are the same cost savings used in the California study. See, Analysis Group, *op. cit.*, p. 8. As noted previously, the starting date of 2016 assumes a ten -year lag from the initial research grants awarded in 2006. While time delays of this order are typical of major medical research, the intense attention world wide on stem cell research may bring much more rapid progress. See, e.g., "Koreans Report Ease in Cloning for Stem Cells," *New York Times*, 20 May 2005, p. 1.

Table 7
Aggregate Medical Treatment Costs
New Jersey, 2016-2025
(Current $)

Disease/Condition	Age Group	Total Treatment Costs ($ millions)
Type 1 Diabetes and LADA	0-64	$13,882
Parkinson's Disease	19 and over	1,953
Spinal Cord Injury		
Incomplete Motor Function	0-64	362
Paraplegia	0-64	934
Low Tetraplegia	0-64	2,518
High Tetraplegia	0-64	3,960
Acute Myocardial Infarction	19-64	28,762
Stroke	19-64	9,384
Alzheimer's Disease		
No nursing home care	19-64	4,624
Nursing home care (incremental)	65 and over	47,063
Nursing home care (total)	65 and over	180,083
Total:	**All**	**$113,440**[1]

1. The estimated cost of spinal cord injuries is allocated among the four degrees of severity according to frequencies cited by the Spinal Cord Injury Information Network. As such, the four costs listed for spinal cord injuries are additive, and all are included in the total. Of the Alzheimer's Disease cost estimates, both the "no nursing home care" estimate for the 19-64 age group and the incremental cost of nursing home care for the 65 and over age group are included in the total. The total cost of nursing home care for the 65 and over group ($180,083 million) is not included in the total.

Table 8
Estimated Medical Cost Savings
New Jersey, 2016-2025
(Current $)

Total 10-Year Treatment Cost: $113.4 billion

Savings Level	Total Savings ($ millions)
1%	1,134.4
2%	2,268.8
10%	11,344.0

1. This total includes the *incremental* cost of nursing home care for Alzheimer's patients over and above the cost of treatment for a non-Alzheimer's sufferer in a nursing home. (See Note 1, Table 7)

estimated 15.1% of total health care spending in New Jersey (these costs included such expenses as Medicaid, State Children's Health Insurance Program, state employee benefits, and state corrections health care). State expenditures on Medicaid were 52.3% of this total.[16]

Table 9 provides the estimates of the health care costs and savings to the New Jersey State budget. The total ten year health care costs to New Jersey of the six conditions is $17.3 billion. The same three reductions in health care costs are assumed, and the estimated savings to New Jersey range from $171.3 million (from a 1% reduction) to $1.7 billion (from a 10% reduction) over the ten-year period from 2016 to 2025. Of these costs, over half are estimated to be savings in state expenditures on Medicaid (shown in Column 3 of Table 9).

It is also, however, important to indicate that the introduction of successful stem cell therapies will also raise health care costs in New Jersey since the therapies will be priced competitively and will be part of health care treatments of these conditions. However, if the therapies are effective in significantly alleviating or curing the health conditions, the costs of the therapies, even if relatively high, are likely to be one-time costs versus the recurring health care costs measured here representing the prevailing current protocols of treatment of these conditions. Accordingly, a significant net saving in health care costs is likely to be realized.

Finally, it is important to state at this point several caveats that accompany these estimates. First, the ultimate effectiveness of stem cell therapies still is unknown and uncertain. Second, restricting the analysis to only these six conditions is likely to understate, and considerably so, the potential benefits of stem cell research since many other health conditions may also be improved significantly. Also, there is no direct causality assumed between New Jersey's investment of $380 million in stem cell research

[16] The percentages for state expenses for total health care costs and state expenditures on Medicaid are from *2000-2001 State Health Care Expenditure Report,* Milbank Memorial Fund, National Association of State Budget Officers, and Reforming States Group, April 2003, and Kaiser State Health Facts, Henry J. Kaiser Foundation, www.statehealthfacts.org.

Table 9
Estimated Cost Savings to NJ State Budget and Medicaid, 2016-2025[1]
(Current $)

Total 10-Year Treatment Cost to New Jersey State Budget: $17.1 billion

Savings Level	Savings to State Budget ($ millions)	Savings to State Medicaid Funds ($ millions)
1%	171.3	89.6
2%	342.6	179.2
10%	1,712.9	895.9

1. For the six diseases studied, we assume that the state budget and Medicaid cover the same percentage of costs as they do for overall state healthcare costs.

and the specific stem cell therapies that would achieve the cost savings estimated here for these health six conditions. Rather, these estimates indicate the very substantial cost savings that potentially can be achieved for the people of New Jersey by effective stem cell therapies. The public policy question is whether New Jersey is going to participate in a significant way in the accelerating worldwide effort in stem cell research.

Work Time and Economic Productivity Savings

Another significant benefit of ameliorating the onset, severity, and/or duration of the six health conditions studied in this report is the savings in lost work time and economic productivity. Simply put, individuals who now suffer from these conditions are constrained, at times, and with varying degrees of severity, from participating fully in the economy. Time lost at work due to hospital stays, sick days, and disability days has obvious costs to employers, the overall economy, and to the individuals affected. In this section, we attempt to estimate the costs to New Jersey of lost work time due to the six health conditions and the potential resulting reductions in these costs that may be attributable to stem cell therapies.

We use the economic value of *incremental* workdays lost due to illness as the measure of the costs of the health conditions studied. The value of a workday is estimated by the average daily wage of the individuals affected. The assumption is that society loses the output that a worker could produce during a workday, but did not due to illness.[17] Thus, we begin the analysis with an estimate of the number of workdays lost in a year for each health condition.

For example, it has been estimated that individuals (aged 18-64) with diabetes lost an *additional* 6.6 workdays a year compared to individuals without diabetes.[18] For the U.S. in 2003, 60.9%[19] of the population aged 19 to 64 was employed full time.

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[17] Workers may be paid for sick days (i.e., a transfer payment is made to compensate them), but the output that they could have produced during that time but did not is a permanent loss for the economy.
[18] See Advanced Medical Technology Association (AdvaMed), "Diabetes Treatment: Medial Technology Savings and Improving Lives." (http://www.advamed.org/VOT/savinglives/diabetes.shtml).

We take the annual prevalence estimates (age group 19-64) of diabetes in New Jersey for 2005 through 2025 and applying the estimate of the percentage of full-time workers to the annual prevalence estimates of diabetes in New Jersey, we then estimate the number of individuals in New Jersey with diabetes that work full time.[20] These estimates are multiplied by the estimated 6.6 days of *incremental illness* due to diabetes to yield annual workdays lost to diabetes by full-time workers in New Jersey. These lost workday estimates are then multiplied by an estimate of the median daily wage for New Jersey full-time workers for each year from 2006 to 2025.[21] These annual estimates are summed for different time periods and listed in Table 10. To appreciate the magnitude of the impact of health conditions on the state's economy, an estimated 241 thousand workdays in New Jersey will be lost in the current year, 2005, due to diabetes. This amount of lost work time is estimated to cost the economy over $43 million in reduced output. For the time periods of this study, diabetes is estimated to result in over 2.5 million work days lost in the ten year period from 2006 to 2015 at a cost of $552 million to the state's economy. In the period when stem cell therapies may become available, 2016 to 2025, there would be an estimated 2.7 million work days lost at a cost of $825 million. Thus, any significant reduction in future workdays lost due to diabetes will result in substantial savings to the state's economy.

We do not have specific estimates of *incremental* workdays lost for the other five health conditions. However, the diabetes estimate of 6.6 workdays represents 2.5% of annual work days (261 days per year). Since the health conditions we examine vary in severity both across and within categories, we apply a conservative estimate of *incremental illness* of 2% (5.22 workdays lost annually) for these other categories. Following the same procedure as used for diabetes above yields the total work days lost

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[19] This percentage is based on the number of people who worked full time for at least 40 weeks in 2003 as reported in "Work Experience of the Population in 2003," Current Population Survey annual economic news release, 2003, available at http://www.bls.gov/news.release/pdf/work.pdf.

[20] We do not estimate work days lost for part-time workers, nor for individuals under the age of 19. Thus, our estimates understate the costs of lost work time.

[21] Median full-time annual earnings in New Jersey are available from the American Community Survey of the U.S. Census Bureau for 2003 ($43,474). This annual earnings estimate is expressed as a daily wage ($166.57) and adjusted by 3.5% annually (the average increase in median income from 1993 to 2003 from Bureau of Labor Statistics data).

Table 10
Value of Lost Workdays, Diabetes
New Jersey, 2005-2025
(Current $)

Year(s)	Workdays Lost (000)	Value ($ millions)
2005	241.1	43.1
2006-2015	2,536.0	552.0
2016-2025	2,681.8	825.0

Table 11
Value of Lost Workdays, 5 Conditions (Excludes Diabetes)
New Jersey, 2005-2025
(Current $)

Year(s)	Workdays Lost (000)	Value ($ millions)
2005	691.0	123.4
2006-2015	7,333.6	1,597.0
2016-2025	7,895.0	2,430.1

Value of Lost Workdays, All Conditions
New Jersey, 2005-2025

Year(s)	Workdays Lost (000)	Value ($ millions)
2005	932.2	166.4
2006-2015	9,869.6	2,149.0
2016-2025	10,576.9	3,255.1

and the value of workdays lost for the five other health conditions. These are listed in top panel in Table 11. In 2005, the five additional health conditions are estimated to result in over 691 thousand workdays lost at a cost of $123.4 million to the state's economy. For the ten-year period from 2006 to 2015, 7.3 million workdays will be lost at a cost of $1.6 billion. In the 2016 to 2025 period, this increases to 7.9 million lost workdays at a cost of $2.4 billion.

The lower panel in Table 11 adds in the diabetes estimates to get the total workdays lost and their value for all of the six health conditions. In the period when stem cell therapies are most likely to be widely available (2016-2025), the total workdays lost in New Jersey are estimated to be 10.6 million days in the absence of stem cell therapies. This amount of lost work would result in a $3.3 billion dollar loss to the state's economy over the ten years. If stem cell therapies are effective in reducing this loss by only 25% (i.e., a very conservative effect), then the state's economy would benefit by $813 million. If stem cell therapies reduce lost work time by 50%, output losses would decline by $1.6 billion.

Value of Premature Deaths Avoided

All of the estimates of the potential benefits of stem cell research made thus far in this report are in terms of what can be characterized as periphery aspects of the essential element at issue. The central benefit and focus of the research, namely, the opportunity that stem cell research provides to alleviate, and possibly eliminate, the human pain, suffering, and anguish caused by particularly severe health conditions has not been addressed. In other words, stem cell research may improve the quality and length of life for individuals who otherwise must live in a difficult, often painful, and, at times, deeply constrained manner. The related human toll such illnesses and injuries impose on the families, spouses, caregivers, and friends of those stricken is equally poignant and burdensome.

The chance to improve the human condition and reduce, or possibly end, such human suffering is so compelling that it must be explicitly acknowledged as the foundation of the commitment of any public resources. Estimates in dollars of the direct economic impact of such expenditures, the possible reduction in health care costs, and the added dollars that result from work time saved are weak substitutes, at best, for capturing the benefits in the quality of life of those who now, and those in future who will, suffer in profound physical and mental ways from the devastating health conditions at issue.

Expressing such value of life benefits in monetary terms may seem crass, or even abhorrent, given the uniqueness of life and the respect and dignity that each life deserves. Yet this report, as preliminary as it is, would be incomplete without attempting to quantify this most basic and fundamental of all the potential benefits of stem cell research. To our knowledge, no other study of the impact of stem cell research has tried this. Even the comprehensive and detailed impact estimation effort made by California states:

> "Were Proposition 71 to accelerate the discovery of beneficial therapies it could produce important benefits ….. throughout the United States and even the world, in the form of improved length of life or quality of life for individuals with affected health conditions….. We do not attempt to quantify the potentially large, but often intangible benefits of this type that could result from successful research…"[22]

However, economists have long tried to estimate the value of human life in order to improve the effectiveness of public expenditures on health and safety. Thus, there is an extensive literature that has provided both methodologies for, and applications of various techniques to estimate the value of life.[23] Examples of public policies to

[22] Analysis Group, *op. cit.,* p. 4.

[23] The approaches used in valuing human life determine people's willingness to pay to reduce fatal risk or the payment people require to accept such risks. Two methods are used: studies of labor markets estimate the compensation required to accept increases in risk; and contingent valuation studies use survey responses to elicit values placed on different levels of risk. For useful reviews of this literature, see, W. Kip Viscusi and Joseph E. Aldy, "The Value of a Statistical Life: A Critical Review of Market Estimates

improve safety or health abound (e.g., better highway design, food additive regulations, emission limits on air pollutants). These policies may save lives and reduce morbidity. The lives saved and the illnesses avoided, not periphery economic impacts, are the core benefits of such policies and are the compelling public rationale that justifies the use of society's scarce resources.

In the case of estimating the value of lives saved, the actual benefit measure is the number of premature deaths avoided. Therefore, what we attempt in this section is to estimate the value of premature deaths in New Jersey avoided as a result of the implementation of effective stem cell therapies. It is important to understand that the value of life calculations estimated here are for anonymous statistical lives, not the value of life of any known individual. The life-saving benefits of a public policy, be it air pollutant emission reductions or stem cell research investments, will reduce illness and death by relatively small percentages in large populations sometime in the future. Thus, we *are not* estimating the value of reducing premature death of any known individual, but rather the value of changes in mortality rates in the future in anonymous populations of individuals projected to suffer from the health conditions examined in this report.

There is ongoing debate in the academic literature about how best to measure the value of the life-saving benefits of any given policy (or in this case, treatment).[24] One approach is to attribute a single value to each life saved (premature death avoided). With value-of-life estimates generally in the range of several million dollars, this approach results in very high estimates of the benefits derived from any policy that saves even a small number of lives.

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throughout the World," *Journal of Risk and Uncertainty*, Vol. 27, No. 1, August, 2003, pp. 5-76; W. Kip Viscusi, "The Value of Life: Estimates with Risks by Occupation and Industry," *Economic Inquiry*, Vol. 42, No. 1, January 2004, pp. 29-48; W. Kip Viscusi, "The Value of Risks to Life and Health," *Journal of Economic Literature*, Vol. 31, No. 4, 1993, pp. 1912-1946, and U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1990-2010*, Report to Congress, Inventory Record EE-0295A, Washington, D.C., 1999.

[24] See, e.g., Cass R. Sunstein, "Lives, Life-Years and Willingness to Pay," Working Paper 03-5, AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C., June 2003, and Per-Olov Johansson, "Is there a meaningful definition of the value of a statistical life," *Journal of Health Economics*, Vol. 20, Issue 1, pp. 131-139.

Because this approach does not account for variation in the age of decedents, and the variation in life expectancy depending on each decedent's age, some argue that it overstates the value that can be attributed to life-saving policies. Instead, it is suggested that a more appropriate approach is to estimate the value of a single year of life (a life-year) and apply this value to the number of life-years that would be saved by a given measure. The number of life years saved would depend on the life expectancies of those who benefit from the policy. This approach generally produces more modest estimates of the benefits of life-saving measures, but also raises ethical questions in that it inherently attributes a lower value to the lives of the elderly than to those of the young. As both approaches to valuing lives saved are widely used in regulatory analysis, we present estimates for each, recognizing that the benefit estimate from the life-years saved approach will necessarily be smaller than that of the lives-saved approach.

The first step in both approaches is to determine the mortality rate among sufferers of each condition. In this case, the mortality rate represents the number of deaths caused by each condition as a percentage of the prevalence of each condition in the state.[25] We use a constant mortality rate specific to each condition to estimate the number of deaths in each age group each year.[26] The mortality rates for each disease and the aggregate number of estimated deaths caused by each disease in the years 2016 through 2025 are reported in Table 12.[27] Mortality rates range from a low of 0.03% among Alzheimer's sufferers in the 19-64 age group to a high of 4.5% among Parkinson's Disease sufferers over the age of 65.[28] We estimate a total of

[25] For an explanation of prevalence estimates, see the section "Savings in Health Care Costs."

[26] For stroke, Parkinson's Disease and Alzheimer's Disease, we base our mortality rates on the number of deaths per age group in 2002 reported by the New Jersey State Health Assessment Data (NJSHAD) system of the New Jersey Department of Health and Senior Services (njshad.doh.state.nj.us). For LADA and Type 1 diabetes, we use the NJSHAD 2002 mortality data for all forms of diabetes. For acute myocardial infarction (heart attack), we base the mortality rate on the American Heart Association's reported MI deaths and prevalence for 2002 (*Heart Disease and Stroke Statistics – 2005 Update*, American Heart Association 2002. Mortality estimates for spinal cord injury are taken from Strauss, David et al., "Long Term Mortality Risk After Spinal Cord Injury," *Journal of Insurance Medicine* 32: 11-16, 2000.

[27] It is possible that new non-stem cell treatments will reduce the mortality rates of all or some of these six conditions in the future. We do not attempt to estimate such changes and the resulting effects on the efficacy of stem cell therapies.

[28] The life saving effects of stem cell therapies are assumed to begin in 2016 (i.e., ten years after the implementation of the research). This has been the assumption used throughout this report. If effective

Table 12
Mortality Rates and Estimated Number of Deaths by Disease/Condition
New Jersey, 2016-2025

Condition	Age Group	Mortality Rate	Number of Deaths	50%	25%
Parkinson's	19-64	0.36%	217	108	54
	65 and over	4.50%	7,108	3,554	1,777
Alzheimer's	19-64	0.03%	128	64	32
	65 and over	2.20%	26,639	13,319	6,660
Spinal Cord Injury	0-18	0.35%	59	30	15
	19-64	0.69%	500	250	125
Stroke	19-64	0.88%	5,716	2,858	1,429
AMI	19-64	2.50%	33,062	16,531	8,266
Type 1 Diabetes and LADA	19-64	0.21%	1,431	715	358
Total			**74,860**	**37,430**	**18,715**

therapies are achieved earlier, the benefits in terms of value of premature deaths avoided (and health care cost savings) will begin sooner and the totals will be larger than the estimates provided here.

74,860 deaths attributed to the five conditions over the ten-year period. Due to its high population prevalence, the greatest number of deaths expected over the ten-year period – 33,062 – is attributed to heart attacks and this represents 44% of the total deaths.

Because it is not clear how effective any given stem cell therapy will be, it is difficult to speculate as to the portion of these deaths that may be avoided by a successful therapy. As such, our calculations address three scenarios: one in which all 74,860 projected deaths are avoided, one in which 50%, or 37,430, are avoided, and one in which 25%, or 18,715, are avoided. These figures are also listed in Table 12.

For the value-of-lives-saved approach, we next need to determine a monetary value to attribute to each life. We begin with a $4.8 million (1990 dollars) value-of-life estimate reported by the Environmental Protection Agency in its 1999 report *The Benefits and Costs of the Clean Air Act, 1990-2010*.[29] This value represents the mean of a distribution of value-of-life estimates reported in 26 studies reviewed by the EPA in its report.[30] We adjust this estimate to approximately $6.9 million in 2004 dollars based on the annual CPI (all goods, all urban consumers) and grow this value into future years at a rate of 2.46%, based on the average percentage increase in the CPI from 1994 through 2004.

Finally, we multiply the number of lives saved each year by the estimated value of a life for each year and sum the results to arrive at an estimate of the total value of premature deaths avoided as a result of stem cell therapies. These results are presented in Table 13. In the most conservative scenario, in which only 25% of projected premature deaths are avoided, we estimate a total value of lives saved of $195 billion ($129.8 billion in 2004 dollars) for the ten-year period beginning in 2016 (the first year of application of an effective therapy). These savings increase to $780 billion ($519.3 billion in 2004

[29] U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1990-2010*, Report to Congress, Inventory Record EE-0295A, Washington, D.C., 1999.
[30] EPA, *op. cit.*, H-7. The EPA takes these estimates from a broader review of value-of-life studies in Viscusi, W. Kip, *Fatal Tradeoffs. Public and Private Responsibilities for Risk*, Oxford University Press. New York, 1992.

Table 13
Estimated Value of Lives Saved
New Jersey, 2016-2025

Condition	Age Group	Projected Premature Deaths	100% Deaths Avoided Scenario		50% Deaths Avoided Scenario		25% Deaths Avoided Scenario	
			Current $ (millions)	2004 $ (millions)	Current $ (millions)	2004 $ (millions)	Current $ (millions)	2004 $ (millions)
Parkinson's	19-64	217	2,251.9	1,503.7	1,125.9	751.8	563.0	375.9
	65 and over	7,108	74,175.5	49,311.2	37,087.7	24,655.6	18,543.9	12,327.8
Alzheimer's	19-64	128	1,334.6	889.0	667.3	444.5	333.7	222.3
	65 and over	26,639	278,647.9	184,804.6	139,323.9	92,402.3	69,662.0	46,201.1
Spinal Cord Injury	0-18	59	615.1	410.6	307.6	205.3	153.8	102.6
	19-64	500	5,193.2	3,467.7	2,596.6	1,733.9	1,298.3	866.9
Stroke	19-64	5,716	59,381.7	39,651.6	29,690.9	19,825.8	14,845.4	9,912.9
AMI	19-64	33,062	343,497.6	229,367.3	171,748.8	114,683.6	85,874.4	57,341.8
Type 1 Diabetes and LADA	19-64	1,431	14,865.8	9,926.5	7,432.9	4,963.2	3,716.4	2,481.6
Total		**74,860**	**$779,963.3**	**$519,332.1**	**$389,981.6**	**$259,666.1**	**$194,990.8**	**$129,833.0**

dollars) in the most optimistic scenario in which all premature deaths are avoided. In all three cases, the greatest "savings" are attributed to avoidance of premature deaths due to Alzheimer's and heart attack.

In the second approach, rather than assign a life-value to each premature death avoided, we instead attribute a value to each year of life saved due to new stem cell therapies. To do this, we first estimate the total number of life-years that would be saved by applying an average number of life-years to each death avoided.[31] In the case of heart attack, diabetes and Alzheimer's Disease, we use existing national estimates of average years of life lost in 2002 for all ages for each disease.[32] For spinal cord injury, stroke and Parkinson's Disease, we use a weighted average of the life expectancies (by age) of those who died from each disease in New Jersey in 2002.[33]

The average life-years saved for each disease and the total number of life-years saved for the 2016-2025 period are presented in Table 14, along with the 100%, 50% and 25% success rates analogous to those in Table 12. Estimates of life-years saved in New Jersey in the most optimistic scenario (100% of premature deaths avoided) range from just over 1,000 among spinal cord injury sufferers aged 0-18 to over 380,000 among heart attack sufferers in the 19-64 age group. Estimates of total life-years saved range from 204,514 in the most conservative scenario (25% of premature deaths avoided) to 818,057 in the most successful case.

Like our value-of-life estimate, we take our estimate of the value of each life-year from the EPA's analysis of the Clean Air Act. The estimate of $137,000 (in 1990 dollars)

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[31] Some approaches go further, adjusting the number of life-years saved according to the severity of the symptoms associated with the conditions or diseases in question to arrive at an estimate of quality-adjusted life years (QALY). See EPA, *op. cit.*, H-9 – H10, for a detailed discussion of this technique.
[32] *Heart Disease and Stroke Statistics – 2005 Update*, American Heart Association 2002; Ries LAG et al. (eds). *SEER Cancer Statistics Review, 1975-2002*, National Cancer Institute. Bethesda, MD, http://seer.cancer.gov/csr/1975_2002/.
[33] Life expectancies are taken from Arias, Elizabeth, "United States Life Tables, 2002," National Vital Statistics Reports, Vo. 53, No. 6. National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. Maryland: November 2004, and Strauss et al, *op. cit*. Deaths by disease by age group are taken from "Death Statistics for the State of New Jersey", New Jersey State Health Assessment Data, New Jersey Department of Health and Senior Services (http://njshad.doh.state.nj.us), and Strauss et al, *op. cit*.

Table 14
Average and Total Life-Years Saved, 2016-2025

Condition	Age Group	Average Life-Years Saved	100% Scenario Total Life-Years Saved	50% Scenario Total Life-Years Saved	25% Scenario Total Life-Years Saved
Parkinson's	19-64	23.7	5,137	2,568	1,284
	65 and over	8.1	57,575	28,787	14,394
Alzheimer's	19 and over	6.9	184,692	92,346	46,173
Spinal Cord Injury	0-18	12.2	1,007	504	252
	19-64	9.6	6,787	3,394	1,697
Stroke	19-64	28.4	162,323	81,162	40,581
AMI	19-64	11.5	380,217	190,109	95,054
Type 1 Diabetes and LADA	19-64	14.2	20,318	10,159	5,080
Total			**818,057**	**409,028**	**204,514**

takes the $4.8 million value-of-life estimate and divides it by 35 years – an estimate of the life expectancy of an average respondent in a mortality risk study.[34] As with the value-of-life estimates, we adjust this value to a 2004 level of $198,000 according to the CPI and grow it into future years using the ten-year CPI average for 1994-2004. We then multiply the value per life-year by the estimated number of life-years saved for each year and sum across years to arrive at a total estimate for the years 2016-2025.

Table 15 presents estimates of the value of life-years saved in both current and 2004 dollars for the 100%, 50% and 25% success scenarios. As noted earlier, the life-years approach is conservative, and results in values less than one-third of those derived from the direct value-of-life approach. Estimates range from $60.8 billion (current dollars) in the least successful scenario to $243 billion (current dollars) in the most optimistic case. Despite these more modest outcomes, it is clear from both approaches that even conservative monetary estimates of the public benefits that could result from successful stem-cell therapies are highly substantial.[35]

Once again, it is important to reiterate that we are *not* concluding that these are the value of life savings that can be attributed fully (and only) to the proposed New Jersey stem cell research initiative. Rather, the estimates indicate the enormous scale of benefits in terms of the value to New Jerseyans of having effective stem cell therapies for these health conditions. New Jersey's contribution to the discovery and implementation of those therapies can be part of a broader national and international effort in stem cell research. The issue, as stated earlier, is whether New Jersey is to be a significant participant in this effort.

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[34] The EPA study cites this method from Moore, M.J. and W.K. Viscusi, "The Quantity-Adjusted Value of Life," *Economic Inquiry* 26(3): 369-388, 1988. In its analysis, the EPA applies Moore and Viscusi's approach to the life-expectancy estimates of its own study, and applies a 5% discount rate to future years, to arrive at a life-year value of $293,000. We use Moore and Viscusi's more conservative, generic estimate.

[35] We have not discounted the estimates of the value of premature deaths avoided as is done in some studies. Instead, we have expressed annual estimated values in current dollars and aggregated these over the 2016-2015 period. The issue of discounting the value of future life years saved, or future lives saved, is controversial. See, e.g., A. Myrick Freeman III, *The Measurement of Environmental and Resource Value: Theory and Methods,* Chapter 10, 2nd Edition, Resources for the Future: Washington, D.C., 2003. Also, we have not attempted to estimate the value of reduced morbidity or changes in the quality of life years. Such benefits may be significant and thus, our estimates may understate the value of life benefits in New Jersey of stem cell therapies.

Table 15
Estimated Value of Life-Years Saved
New Jersey, 2016-2025

Condition	Age Group	Life-Years Saved	100% Deaths Avoided Scenario Current $ (millions)	100% Deaths Avoided Scenario 2004 $ (millions)	50% Deaths Avoided Scenario Current $ (millions)	50% Deaths Avoided Scenario 2004 $ (millions)	25% Deaths Avoided Scenario Current $ (millions)	25% Deaths Avoided Scenario 2004 $ (millions)
Parkinson's	19-64	5,137	1,523.3	1,017.1	761.6	508.6	380.8	254.3
	65 and over	57,575	17,148.4	11,400.1	8,574.2	5,700.1	4,287.1	2,850.0
Alzheimer's	19-64	884	262.8	175.1	131.4	87.5	65.7	43.8
	65 and over	183,808	54,876.1	36,394.9	27,438.1	18,197.4	13,719.0	9,098.7
Spinal Cord Injury	0-18	1,007	298.9	199.5	149.4	99.7	74.7	49.9
	19-64	6,787	2,012.5	1,343.9	1,006.3	671.9	503.1	336.0
Stroke	19-64	162,323	48,133.8	32,140.9	24,066.9	16,070.4	12,033.4	8,035.2
AMI	19-64	380,217	112,745.7	75,284.9	56,372.9	37,642.4	28,186.4	18,821.2
Type 1 Diabetes and LADA	19-64	20,318	6,025.0	4,023.1	3,012.5	2,011.6	1,506.2	1,005.8
Total		**818,057**	**$243,026.5**	**$161,979.4**	**$121,513.2**	**$80,989.7**	**$60,756.6**	**$40,494.9**

Retention and Expansion of Biotechnology and Pharmaceutical Industries

A large number of 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 economics 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 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."[36] The pharmaceutical industry is a much broader and more mature business 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 types of industry - - biotechnology and pharmaceutical - - have a significant presence in New Jersey and both represent very important parts of the state's economy.

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[36] 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.

The question examined in this section is how will the proposed stem cell initiative affect these industries. To analyze this, it is useful to have a sense of the size of these business sectors. Table 16 provides data from the Economic Censuses of 1997 and 2002 for the four components of the broadly defined pharmaceutical and medicine manufacturing industry for the United States and New Jersey.[37] The Economic Censuses offer a consistent definition of and consistent measures for the industry in terms of the number of establishments[38], total receipts (sales revenue), and employment. The size of the industry nationally is significant. The Census reveals that in 2002, the industry consists of 1,800 establishments, with \$140.7 billion in annual sales, and employing 251,783 people. The number of establishments increased by 39 over 1997 (2.2%). Sales revenues were up by \$47.7 billion (51.4%), and total employment rose by 48,446 (23.8%). New Jersey had 136 establishments in 2002, an increase of nine from 1997 and sales were \$13.1 billion, a gain of 2.6% since 1997. Employment totaled 31,164 jobs in 2002, up by a large 41.6% since 1997.[39] New Jersey had a 10.7% share of the national total of establishments, 10.4% of the national sales, and 15.4% of the national employment in the industry in 2002. New Jersey's share of establishments and employment were down slightly from 1997, while its share of sales declined significantly (from 16.2% in 1997 to 10.4% in 2002).

Biotechnology firms, however, are businesses whose primary activity is *research* aimed at the development of new products and are not included in the pharmaceutical and medicine manufacturing categories listed in Table 16. Rather, biotechnology firms are measured separately by the Economic Census under the NAICS business *services* (i.e.,

[37] The industry is measured by the U.S. Bureau of Census according to the North American Industrial Classification System (NAICS). There are four components within the NAICS industry group 3254 code and these are listed in Table 16. Definitions of these components are given in Section A-4 of the Appendix.

[38] The Economic Census definition of establishments is all establishments with payroll at any time during the years of the Census.

[39] The New Jersey data are for the medicinals and botanicals category plus the pharmaceutical category only since data for the other two components (diagnostic substances and biological products) are not yet available for 2002. However, the two components where data are available represent a large part of the total (nationally, these two components accounted for nearly 90% of the sales of the total for all four components of the industry). We use the Economic Census estimates to measure the industry since they provide consistency for the relationship among establishments, revenues, and employment. Separate BLS estimates for New Jersey using NAICS codes are available for employment and generally indicate larger levels of employment than the Census numbers. However, accompanying data for sales revenues and establishments are not available.

Table 16
Pharmaceutical Industry Profile
United States and New Jersey, 1997-2002

UNITED STATES

		Establishments[1]				Receipts				Employment			
				Change				Change				Change	
NAICS	**Sector**	**1997**	**2002**	**Num.**	**%**	**1997**	**2002**	**Number**	**%**	**1997**	**2002**	**Number**	**%**
325411	Medicinals/ Botanicals	338	367	29	8.6	11,888,455	11,585,499	-302,956	-2.5	27,764	19,938	-7,826	-28.2
325412	Pharmaceuticals	832	901	69	8.3	66,734,737	113,991,849	47,257,112	70.8	114,119	182,149	68,030	59.6
325413	Diagnostic Substances	228	236	8	3.5	8,682,377	7,296,122	-1,386,255	-16.0	38,485	26,838	-11,647	-30.3
325414	Biological Products, except Diagnostic	363	296	-67	-18.5	5,627,217	7,790,703	2,163,486	38.4	22,969	22,858	-111	-0.5
325411+ 325412	**Med./Bot.+ Pharma.**	1,170	1,268	98	8.4	78,623,192	125,577,348	46,954,156	59.7	141,883	202,087	60,204	42.4
32541	**Total**	1,761	1,800	39	2.2	92,932,786	140,664,173	47,731,387	51.4	203,337	251,783	48,446	23.8

NEW JERSEY

		Establishments				Receipts				Employment			
				Change				Change				Change	
NAICS	**Sector**	**1997**	**2002**	**Num.**	**%**	**1997**	**2002**	**Number**	**%**	**1997**	**2002**	**Number**	**%**
325411	Medicinals/ Botanicals	28	37	9	32.1	1,401,392	2,437,708	1,036,316	73.9	3,297	4,869	1,572	47.7
325412	Pharmaceuticals	99	99	0	0.0	11,357,855	10,658,847	-699,008	-6.2	18,719	26,295	7,576	40.5
325411+ 325412	**Med./Bot.+ Pharma.**	127	136	9	7.1	12,759,247	13,096,555	337,308	2.6	22,016	31,164	9,148	41.6
5417102	**R&D in the Life Sciences**	n/a	281	n/a	n/a	n/a	1,096,480			15,411			
	Total: Mfg. + R&D		**417**				**14,193,035**			**37,427**			

1. Establishments refers to all establishments with payroll at any time during the years. This is distinct from the Census definition of "company," which refers to a business organization consisting of one establishment or more under common ownership control.

not *manufacturing*) category of professional, scientific, and technical services. Specifically, the NAICS title for these firms is "Research and development in the life sciences" (NAICS Code 5417102).[40] The data for these businesses in New Jersey appear in the next to last line of the New Jersey panel in Table 16. In 2002, the state had 281 establishments with $1.1 billion in revenue and employing 15,411 people. It is this sector that we believe will be the most affected and assisted by the stem cell initiative since it contains the dynamic, relatively small firm, research focused aspects of biotechnology economic activity.

Three scenarios are examined with respect to the possible effects of the stem cell initiative on the biotechnology industry in New Jersey. First, we estimated the negative effects that may occur if the focus of biotechnology shifts significantly to other areas of the country, or to outside the United States. There is intense competition in stem cell research, and other states and nations have mounted much larger and more ambitious efforts. In addition, the ethical debate over embryonic stem cell research at the national level has placed the country as a whole in a disadvantageous position relative to other countries where support of stem cell research in terms of the commitment of public resources has proceeded unencumbered by the divisiveness and accompanying uncertainties that are prevalent in the United States.

As a second scenario, we estimate the possible positive effects on the biotechnology sector in New Jersey as a result of public expenditures on stem cell research. In this scenario we assume that these expenditures increase the viability and the level of economic activity in the industry. As a third, more optimistic and aggressive, scenario, we estimate the economic effects that would result from an acceleration in the rate of growth of the industry attributable to the stem cell initiative. Finally, there is a discussion of the relation of the stem cell initiative to the broader pharmaceutical and medicine manufacturing industry in the state.

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[40] 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.

The first scenario that we estimate is a pessimistic one. In this situation, New Jersey does not implement the stem cell research initiative and, as a result, New Jersey is not seen by academic scientists and emerging biotechnology firms as an attractive site for stem cell research. The locus and focus of U.S. stem cell work, highly competitive to start, instead, centers on other locations, e.g., California and/or Massachusetts, and a sizeable component of the related biotechnology activity in New Jersey leaves the state. In addition, emerging biotechnology firms that work with stem cells seek out these other locations as agglomeration economies and the intellectual and commercial synergies associated with proximity to others in the industry attract the new start-ups.[41] Accordingly, in this scenario we assume that New Jersey will lose 20% of its biotechnology base over the next three years. This implies a reduction of $298.4 million in annual sales revenue and a permanent loss of approximately 2,167 jobs.[42] These losses, in turn, would have negative multiplier effects. The state would lose an additional 1,205 jobs, total income would decline by $213.9 million, and gross state product would be reduced by $226.7 million. In addition, state tax revenues would decline by almost $8.7 million, with collections dropping by over $3.8 million from businesses and by almost $4.9 million from New Jersey households.

In the second scenario there is a more optimistic outcome. The New Jersey stem cell initiative is promptly implemented and the state remains an attractive scientific environment for scientists and businesses in the related biotechnology areas and the biotechnology industry continues on its current growth path. We assume that sales

[41] Biotechnology businesses are characterized by high failure rates and there is a constant flow of business births and deaths. Estimates indicate that 50% of the biotechnology firms established since 1970 have failed or been acquired by other businesses (see, M. Dibner, *Biotechnology Guide U.S.A.*, Institute for Biotechnology Information, Research Triangle Park, N.C., September, 1999). If New Jersey begins to lose out on the formation of new biotechnology businesses, but the high, normal business mortality rate continues for the existing stock of biotechnology firms, then the overall size of the industry will rapidly decline.

[42] We increase the sales levels as reported in the 2002 Economic Census in order to establish a baseline measure of the size of annual sales in the biotechnology industry in New Jersey in 2004. Sales are increased (conservatively) by 8% a year from 2002 (between 1997 and 2002 national sales of the research and development in the life sciences sector, NAICS code 5417102, increased by over 42% per year). Employment in the same industry code increased nationally by 3.3% a year from 1997 to 2002, but fell by 3.8% per year over the same time in New Jersey in a slightly broader industry category (NAICS code 5417, scientific research and development services). Thus, we use the 2002 employment level in New Jersey as a conservative estimate the baseline level of employment in 2004.

increase by 8% per year for a five-year period (2006-2010) and then decline to a 5% annual growth rate for a fifteen-year period (2011 to 2025).[43] The stem cell initiative, with its injection of capital, equipment, and research dollars is assumed to attract additional private economic activity in the biotechnology sector. This takes the form of added private investment for both capital and research. We conservatively assume three different matching ratios for each $1 in public spending ($1, $1.50 and $2.00).[44] Table 17 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.[45] Using a $1 to $1 match assumption, the cumulative investment over the 2006 to 2025 period is $1.34 billion. This difference increases to $1.8 billion for a $1.50 to $1 match, and $2.3 billion for a $2 to $1 match. Taking the mid-range $1.50 to $1 matching scenario, this results in $1.8 billion in capital, equipment and research spending. However, the impacts of the $380 million in public funding are part of the $1.8 billion in investment spending and have already been accounted for in Table 4. Of the remaining $1.4 billion in private funding, approximately $1.2 billion would go toward research and development, with an additional $225 million invested in construction and equipment. Table 18 presents the impacts of each type of spending. Together, these private investments would result in the creation of 15.8 thousand job years and lead to an increase in GSP of $1.1 billion (current dollars). They would also result in an additional $40.3 million in state tax revenues and $44.4 million in local taxes.

In the final scenario, the New Jersey stem cell initiative is assumed to have an even more aggressive outcome. In this case, the state becomes a primary locus of stem

[43] As noted, 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 this report.
[44] The Analysis Group report indicates that historically there has been $2.80 in private investment in research and development for each $1 in public funding. See Analysis Group, *op. cit.,* p. 44.
[45] We assume the additional private investment in research continues after 2012 (the year the $230 million in state research investment ends). The annual private investment is adjusted upward after 2012 by 4.2% annually, the historical increase in health care costs used throughout this report.

Table 17
Public and Private Matching Investment in the Biotechnology Industry, 2006-2025
(Current $)

Private/Public Match Ratio	Total Investment
$1 to 1	$1.34 billion
$1.50 to 1	1.81 billion
$2.00 to 1	2.29 billion

Table 18
Economic Impacts of $1.2 Billion in Private Funding for Facilities and Equipment and $225 Million for Research and Development: 2006-2025
(Current $)

	Employment	Income ($ millions)	GSP ($ millions)	State Taxes ($ millions)	Local Taxes ($ millions)
Capital Investment	2,092	114.7	136.3	5.1	5.7
R&D Investment	13,670	867.3	919.1	35.2	38.7
Total	**15,762**	**$982.0**	**$1,055.4**	**$40.3**	**$44.4**

cell research as support from the larger pharmaceutical industry provides tangible resources, visibility, and confidence that New Jersey is the place to do this work. The academic institutions in New Jersey, particularly Rutgers University and the University of Medicine and Dentistry, become sought out destinations for top scientists and undergraduate and graduate students working in stem cell research, the supporting infrastructure of facilities, equipment, and space is both ample and state of the art. As a result, the increase in the entire biotechnology industry in the state accelerates. In this scenario, the *rate of growth* of sales is assumed to increase over the baseline forecast in addition to the leveraging of private investment as a match to the public investment. Specifically, we assume that the annual sales growth rate is 8% between 2006 and 2010 (the same as in scenario 2), but decreases to only 7% (not 5%) from 2011 to 2025. This faster growth rate would amount to a total net increase in biotechnology sales of approximately $8.6 billion over the baseline growth scenario (5%) for the 15-year period. This would create an additional 97,000 job years and an estimated $6.2 billion in income (current dollars). GSP would increase by $6.5 billion, which, together with household taxes of $1.25 billion, would yield a positive impact of $7.75 billion in New Jersey, including $275 million in local taxes and $250 million in state taxes.

Finally, we have not estimated any effect on the stem cell research initiative on the broader (and much larger) New Jersey pharmaceutical manufacturing industry (i.e., the industry whose data are reported in Table 16). The industry will have obvious interests in potential commercial opportunities that may emerge from stem cell research but it is not clear what current stem cell work, if any, is being done in the industry. Worldwide strategic business interests and long-term planning by these firms chart their future course, and the role of stem cell within that process at present is uncertain.

However, it is noteworthy that the industry has been subject to intense competition, numerous restructurings and mergers, and increased federal oversight. In New Jersey, employment levels in manufacturing pharmaceuticals declined during the 1990s (from 41,900 in 1990 to 35,200 in 1997) but have recovered since so that the overall level of employment in 2004 is 40,200, close to the 41,900 level of 1990).[46] A case can be made that a strong biotechnology industry in New Jersey with a specialization in stem cell research will complement and assist the pharmaceutical industry. At the same time, the presence of the thriving and large pharmaceutical industry can significantly enhance the state's stem cell initiative through its active and visible support and investment as outlined in scenario three above.

Royalty Payments to New Jersey

Part of the proposed protocols for the $230 million in research grants specify that New Jersey will receive intellectual property rights from any therapies that are developed from work supported by these funds. Obviously, there is great uncertainty as to whether any successful therapies (in both a clinical and commercial sense) will emerge from stem cell research. There are long time lags between research and clinical trials, the procedures for drug 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.

Previous break-through biotechnology therapies are estimated to have generated $3 billion in sales per drug over the patent life.[47] 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 NJ project (2016). These revenues are indexed upward by 4.2% annually to reflect

[46] These totals are from the Bureau of Labor Statistics according to NAICS 32541 and differ from the Economic Census estimates. In addition, because of the redefinition of the NAICS codes vis a vis the SIC codes these data do not include headquarters management functions nor research and development and thus understate the industry's presence (in New Jersey and nationally).
[47] 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.

historic yearly price increases in health care. Annual sales revenues are assumed to start at $409.5 million in year one and increase to $1 billion by year seven. These revenues sum to the equivalent of the inflation adjusted $3 billion total in 2004 dollars in years 2016 through 2022.

The proposed royalty rate for New Jersey is 1% and we apply this rate to the annual estimates of sales over the seven years. The resulting annual royalty revenues to New Jersey are then summed over the seven years of assumed useful patent life.[48] This produces an estimated royalty revenue total of $56.7 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).[49] We assume this cost increases by 4.2% per year based on historic inflation rates in health care and we further assume that the $230 million in research grants are awarded in equal annual amounts ($32.8 million) over seven years beginning in 2006. 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 .376 therapies created by the investment of $230 million in stem cell research. This estimate of .376 therapies is then multiplied by the total royalty revenues per therapy ($56.7 million) to obtain an estimate of $21.3 million (current dollars) in expected royalty income for New Jersey.

We conclude, as a conservative estimate, that New Jersey could receive $21.3 million in royalty revenues from its support of stem cell research. This is due to the fractional value of a successful therapy (.376) generated from the amount of state research support provided. If, however, the state research support is successful, in a most

[48] 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.
[49] See Analysis Group, *op. cit.,* p. 82, using a Frost and Sullivan Report, 21 January 2004.

favorable case, and results in one effective therapy *directly and completely* from the research support it provides, then an upper bound would be the $56.7 million in estimated royalty revenues from a single successful therapy.

Finally, it is important to again 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 discussed in a previous section. 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 and Conclusions

This report provides a preliminary analysis of the potential economic benefits of the New Jersey stem cell initiative. The analysis is complex and dependent upon many variables. The largest uncertainty, of course, is whether the current promise of stem cell research will, in time, yield effective therapies. This uncertainty should be placed in the context of the historic advance of medical science. Scientific breakthroughs such as inoculations, vaccinations, antibiotics, organ transplants, and a host of others all were subject to doubt, and often, criticism. Yet such discoveries, and the research that led to them, have saved countless lives and alleviated deep suffering for millions of people throughout the world. Medical advances based on research have improved life expectancies and the quality of human life repeatedly and significantly.

Moreover, although this report examines six specific health conditions that are (by current thinking) most likely to benefit from stem cell research, it may be that not all of these conditions will be alleviated or cured by stem cell therapies. However, stem cell therapies for other widespread and costly diseases and health conditions not considered here may be developed as part of the basic research process.

One summary of the potential total benefits of the New Jersey initiative is to aggregate those components that can, with some degree of confidence, be assigned directly to the initiative. These are: the economic impact of the public expenditures, the retention and expansion of the biotechnology industry in New Jersey, and the potential royalty payments to the state. Our estimates of the benefits to New Jersey of these three effects are presented in Table 19. The public expenditure component of the initiative is estimated to directly generate $335.7 million in economic activity and 4,061 jobs. Also, according to a conservative scenario that assumes that the initiative assists in the retention and development of the biotechnology industry in the state, economic output in New Jersey increases by a further $1 billion and 15,762 additional jobs are created. Finally, and again using a conservative assumption with respect to the intellectual property that may result from state support of stem cell research, there will be an estimated $21.3 million in royalty payments to the state. The aggregate of the three effects is a gain of $1.4 billion and nearly 20,000 new jobs for New Jersey's economy. State revenues (taxes and royalties) are estimated to increase by $71.9 million as a result of these three benefit components.

A broader and additional dimension of the potential total benefits is to aggregate those components that would accrue to New Jersey, in time, if effective stem cell therapies were developed anywhere in the country, or in the world. The assumption is that effective stem cell therapies would be applied in New Jersey and result in health care cost savings, reductions in lost work time, and decreases in premature deaths.

As noted in the corresponding sections in the report, we are *not* attributing all the benefits estimated for these three components to the $380 million New Jersey stem cell initiative. Instead, our intent is to identify these as important and substantial potential effects of stem cell therapies and to estimate the scale and scope of the benefits that New Jersey would realize should effective therapies be found and implemented on a wide-scale. The public policy issue is whether New Jersey will be a significant partner in the larger national and international research effort seeking effective therapies. The benefits that result from these three effects are listed in Table 20.

We again use conservative assumptions for this aggregation process. Specifically, we assume that effective stem cell therapies will reduce New Jersey's health care costs by 10% beginning in 2016, and we only estimate total savings for a ten-year period from that date. This results in a total health care costs savings of $11.3 billion, and of that, state budget savings are $1.7 billion. We also assume only a 25% reduction in workdays lost as a result of effective stem cell therapies for the six conditions and a 25% reduction in premature deaths. The 25% decrease in workdays lost results in a $813 million gain in economic output. The 25% reduction in premature deaths is valued at $60.8 billion. The total of all three of these benefit components is nearly $73 billion over the ten-year period.[50]

Examining only the state fiscal effects, we estimate that there will be a gain of $1.8 billion in additional state taxes, royalties, and lower state financed health care costs. Again, it is important to note that adding the health care cost savings to the taxes and royalties to obtain the $1.8 billion estimate does not assume that the New Jersey stem cell initiative is the full and sole cause of the health care savings. Rather, it demonstrates the order of magnitude of fiscal benefits to New Jersey from being part of the international effort to discover and implement stem cell therapies.

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 life-time 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

[50] We reiterate that we have not discounted the future flow of benefits for several reasons. First, the purpose of our report is not to conduct a benefit/cost analysis of the state's expenditures. Second, as noted previously, there is controversy in the field because of intergenerational equity issues as to whether to discount changes in future mortality and morbidity.

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 a large radio telecommunications industry. Rutgers University Professor Selman Waksman and his student Albert Schatz's explorations into soil bacteria led to the development of streptomycin and 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 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.

Table 19
Benefits Directly Attributable to New Jersey Stem Cell Initiative
(Current $)

	Economic Impact ($ millions)	Employment
Public Expenditures on Stem Cell Research	335.7	4,061
Retention and Expansion of the Biotechnology Sector[1]	1,055.4	15,762
Patent Royalties	21.3	
Total	**1,412.4**	**19,823**

Total State Revenue: $71.9 Million

1. We use the second scenario analyzed in the text, i.e. there is private matching of the state investment at a ratio of $1.50 to $1. This matching continues for the research expenditures after the public research grants end.

Table 20
Effect of Stem Cell Therapies on New Jersey, 2016-2025
(Current $)

	Economic Impact[1] ($ millions)
Health Care Cost Savings	11,344
Savings to State Budget	1,713
Work Loss Reductions	813
Premature Deaths Avoided	60,757
Total	**$72,914**

1. Conservative estimates are used for all three benefits. We use estimates for a 10% reduction in medical costs, a 25% savings on the projected value of lost workdays, and a 25% reduction in life-years lost.

APPENDIX

A-1. Sources for Prevalence Estimates

Estimates for the prevalence of each of the six conditions – diabetes, Parkinson's Disease, spinal cord injury, acute myocardial infarction, stroke and Alzheimer's Disease – are derived by applying national prevalence rate estimates for each condition in each age group to population estimates for each age group interpolated from New Jersey Department of Labor population projections. Following are the sources for the prevalence rate estimates and the total prevalence estimates for 2016-2025.

Condition	Age Group	Source	Basis
Type 1 Diabetes	0-18	Analysis Group, p. 59	CDC and other national estimates
Type 1 Diabetes	19-64	Analysis Group, p. 60; CDC diabetes prevalence estimates for 18-65 year olds in New Jersey, 2000-2002 and U.S. Census population estimates	
LADA	19-64	Analysis Group, p. 60	CDC and other national estimates
Parkinson's Disease	19-64	Analysis Group, p. 60-61	NIH, American Geriatrics Society
Parkinson's Disease	65 and over	Analysis Group, p. 60-61	
Spinal Cord Injury	All Ages	Overall prevalence: Analysis Group, p. 61, Frequency distribution of injury severity: Spinal Cord Injury Information Network (www.spinalcord.uab.edu)	National Estimates
Acute Myocardial Infarction	19-64	Analysis Group, p. 62	American Heart Association, National Heart, Lung and Blood Institute
Stroke	19-64	Analysis Group, p. 62	American Heart Association, U.S. Census data
Alzheimer's Disease	19-64	Analysis Group, p. 63	National estimates; Sloane, et al, "The Public Health Impact of Alzheimer's Diseases, 2000-2050: Potential Implication of Treatment Advances" *Annual Review of Public Health*, 2002.
Alzheimer's Disease	65 and over	GAO, *Alzheimer's Disease: Estimates of Prevalence in the United States*, January 1998, p. 6	

A-2. Prevalence Estimates: New Jersey, 2016-2025

Disease/Condition	**Age Group**	**Number of Sufferers**
Type 1 Diabetes	0-18	49,334
	19-64	202,554
LADA	19-64	464,660
Parkinson's Disease	19-64	59,572
	65 and over	157,488
Spinal Cord Injury	0-18	14,095
	19-64	59,572
Acute Myocardial Infarction	19-64	1,322,494
Stroke	19-64	649,333
Alzheimer's Disease	19-64	392,048
	65 and over	1,220,668
Total	**All**	**4,591,818**

A-3. Treatment Cost Estimates

All pre-2004 estimates derived from the following sources were adjusted to 2004 levels using the medical CPI where appropriate. They were then extrapolated through 2025 using the Analysis Group's estimated historical 10-year medical inflation rate of 4.2%.

Condition	Source	Explanation
Diabetes	Votey, Scott R., MD, and Peters, Anne L., MD. "Diabetes Mellitus, Type 1 – A Review." Published on www.emedicine.com. (article address: www.emedicine.com/emerg/topic133.htm).	Votey and Peters estimate that the annual per capita cost of health care for people with diabetes in 1997 was $10,071 and the cost for those without diabetes was $2,699. The incremental cost of treatment is thus $7,372, which is then indexed forward to 2004 using the annual medical CPI for 1997 and 2004, and beyond that using the Analysis Group's estimated annual medical inflation rate of 4.2%.
Parkinson's Disease	Parkinson's Action Network (www.parkinsonsaction.org).	The organization estimates the annual cost of medical care for early-stage Parkinson's at between $2,000 and $7,000. We use the average of $4,500 for all sufferers.
Spinal Cord Injury	Spinal Cord Injury Information Network (National Spinal Cord Injury Statistical Center, University of Alabama): www.spinalcord.uab.edu	The NSCISC provides post-first-year annual cost estimates for treatment of four degrees of injury severity: high tetraplegia, low tetraplegia, paraplegia, and incomplete motor function at any level.
Acute Myocardial Infarction	Analysis Group, pp. 64-66	Extrapolated from Analysis Group's 35-year estimates.
Stroke	Taylor, Thomas N. et al. "Lifetime Cost of Stroke in the United States." *Stroke* v. 27, 1459-1466. American Heart Association, Inc.: 1996.	We use the average (non-weighted) of the incremental long-term annual follow up costs for the under 45, 45-54, and 55-64 age groups in 1990.
Alzheimer's Disease	Ernst, Richard L. and Hay, Joel W. "The US Economic and Social Costs of Alzheimer's Disease Revisited." *American Journal of Public Health*, Vol. 84, No. 8: 1261-1264. August 1994.	We use Ernst and Hay's 1991 incremental estimates for physician care and paid home-care, as well as their estimates for the incremental cost of nursing home care and estimated total cost of nursing home care.

A-4. NAICS Sector Definitions

NAICS 32541: Pharmaceutical and Medicine Manufacturing
This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing biological and medicinal products; (2) processing (i.e., grading, grinding, and milling) botanical drugs and herbs; (3) isolating active medicinal principals from botanical drugs and herbs; and (4) manufacturing pharmaceutical products intended for internal and external consumption in such forms as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

NAICS 325411: Medicinal and Botanical Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing uncompounded medicinal chemicals and their derivatives (i.e., generally for use by pharmaceutical preparation manufacturers) and/or (2) grading, grinding, and milling uncompounded botanicals.

NAICS 325412: Pharmaceutical Preparation Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing in-vivo diagnostic substances and pharmaceutical preparations (except biological) intended for internal and external consumption in dose forms, such as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

NAICS 325413: In-Vitro Diagnostic Substance Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing in-vitro (i.e., not taken internally) diagnostic substances, such as chemical, biological, or radioactive substances. The substances are used for diagnostic tests that are performed in test tubes, petri dishes, machines, and other diagnostic test-type devices.

NAICS 325414: Biological Product (except Diagnostic) Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing vaccines, toxoids, blood fractions, and culture media of plant or animal origin (except diagnostic).

5417102: Research and Development in the Life Sciences
Establishments primarily engaged in conducting research and experimental development in medicine, health, biology, botany, biotechnology, agriculture, fisheries, forests, pharmacy, and other life sciences including veterinary sciences.

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Additional Data Sources

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Kaiser State Health Facts, The Henry J. Kaiser Family Foundation (www.statehealthfacts.org)

National Diabetes Information Clearinghouse, National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), National Institutes of Health (http://diabetes.niddk.nih.gov)

National Spinal Cord Injury Association (www.spinalcord.org)

New Jersey State Health Assessment Data (NJSHAD), New Jersey Department of Health and Senior Services (http://njshad.doh.state.nj.us)

Parkinson's Action Network (www.parkinsonsaction.org)

Spinal Cord Injury Information Network, National Spinal Cord Injury Statistical Center (NSCISC), University of Alabama (www.spinalcord.uab.edu)

U.S. Census Bureau (www.census.gov)

U.S. Bureau of Labor Statistics (www.bls.gov)

WISQUARS (Web-based Injury Statistics Query and Reporting System), National Center for Injury Prevention and Control, Centers for Disease Control and Prevention (http://www.cdc.gov/ncipc/wisqars/)

Wrong Diagnosis (www.wrongdiagnosis.com)