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Thanks for inviting me to speak about the "Budgetary and Policy Context for R&D in FY 2009," the theme of this morning's session. It's hard for me to believe this is the seventh time I've appeared at this Policy Forum as the President's Science Advisor and head of the White House science advisory apparatus. It must be just as hard for YOU to believe it, but here I am. Will it ever be possible for any of my successors to appear *eight* times? It would be difficult, given the lengthening time for clearances and the difficulty of finding qualified people at the beginning of each new Administration to accept the heavy responsibilities, reduced compensation, and high workload – not to mention extraordinary public exposure – of senior federal appointments. "The Policy Context for R&D in FY2009" begins immediately with the need for scientists and engineers who may be recruited by the next President to prepare themselves to say "yes" despite what may seem to be enormous down-sides to this and other senior positions in the Executive branch. Whoever becomes President, whatever party gains or loses power, and regardless of the specific policy environment in the next Administration, our government needs men and women who understand the science and engineering machinery in our society, and are prepared to make it work for our nation.

An invitation to serve in a senior politically appointed position is not an invitation to bargain with the Administration about significant policy issues, as many of my science colleagues tend to do. There isn't enough time for that. If you really want to help science, you help it regardless of the "Policy Context". Policies significant for science get shaped over a long period of time, very rarely overnight. But beginnings are important. Things need to get started immediately to take advantage of the sense of opportunity that always occurs with a new Congress and a new Administration. I came to Washington nine months after the term had begun, and things were already rolling by that time. Of course the main event that shaped my own first term in the White House was the terrorist attacks of 9/11. That was the theme of my first Policy Forum Address seven years ago, and I don't intend to revisit it today. But I do want to make the point that there is important work to be done here, and much of it cannot be done through the advisory boards, commissions, committees and think tanks that academic scientists favor. Too many talented and experienced scientists and engineers who express interest in powering the nation's science machinery hang back from doing it as federal employees.

So let me praise the American Association for the Advancement of Science and a long list of partner organizations for sponsoring and expanding the all-important AAAS Fellows programs that not only increase Washington's technical sophistication, but also spread appreciation among technical communities for how Washington works, and the nature of its rewards for a scientist or engineer. My office, OSTP, has many former AAAS Fellows, and many of those spent some time as staff to members of the House Science Committee and other Hill committees relevant to our mission. OSTP itself has been a significant training ground for people who continue careers in government or policy positions in the private sector. I hope to see some AAAS Fellowship alumni in important offices early in 2009.

The concept of a Policy Context is deeper than you might imagine. The concept of a Policy itself is deeper than you might imagine. As I mentioned in one of these talks years ago, my favorite science policy paper is one that Daniel Sarewitz wrote in 2003 called "Does Science Policy Exist, and If So Does it Matter?" One of the positive events in science policy scholarship during the past year is that Dan finally published his paper in the Summer 2007 issue of the National Academies Journal "Issues in Science and Technology." The important insight of this paper is that try as one might – and generations of science advisors have labored on this – the process of policy implementation in American government is shared over so many uncoordinated actors that the policy behavior of the governmental science machinery is not only different from what policy makers intended, but sometimes difficult to trace at all. Anyone who wants to evaluate the effectiveness of a policy first has to decide what the policy is "on the ground" as opposed to some theory of it embedded in a law or a strategic planning document. The actual outcome of the process of policy proposal, authorization, and appropriation rarely resembles what any particular stakeholder in the process hoped for at the beginning.

That has certainly been true for the past two years during which two different Congresses failed to appropriate science funding in patterns that were worked out over months by their own authorization and appropriations committees. Most observers predict that once again the forthcoming fiscal year will begin with a Continuing Resolution (which translates as Continuing Irresolution). I think there is a danger of reading too much into this extraordinary failure of process. On Sarewitz's model of real world policy implementation, such things are to be expected in general.

Another insight of Sarewitz's paper, to which I have repeatedly called attention because of its importance for forecasting the outcomes of policy struggles in Congress, or between the Executive and Legislative branches, is the remarkable stability of federal R&D funding as a percentage of the domestic discretionary budget. Exactly how this happens each year is somewhat mysterious. It's like trying to infer the laws of thermodynamics from the behavior of the individual molecules in a gas. The small scale motion is chaotic and irreproducible, but the overall behavior always comes out the same.

The big picture of the national budget really matters. As Kei Koizumi emphasizes at the beginning of his presentations each year, the discretionary budget is under constant and growing pressure from the large mandated portion of the budget. On top of this are huge fluctuations associated with events that may seem highly singular and catastrophic, such as war, hurricanes, and economic bubbles, but recur in nearly every Administration. Regardless of the circumstances, the give and take of politics, including all the partisan dealing, all the lobbying, and all the local issues that intrude on the national scene, ends up giving research about the same fraction of the discretionary budget every year in Administration after Administration. The time series has bumps, but they rarely range outside a narrow band.

Many have complained about the impact of the 2008 Omnibus Bill on research. It did have negative effects, which I will mention in a moment, but the Omnibus Bill did provide increases for some important science areas, just not as much as the President's proposal, and much less than the appropriations bills being considered in the subcommittees. And of course it did not reflect the priorities for funding either in the President's American Competitiveness

Initiative, or in Congress's America COMPETES authorization bill. As the dust settles, however, once again research will have received approximately its usual slice of the pie.

I think this pattern will likely persist in future Administrations. I think it will actually be difficult to match the increases in research funding that have occurred during the Bush years. There is much mythology about this, and much quibbling about definitions and what the numbers really mean, but overall there is a much greater amount of research money on the table today than there was at the beginning of the Administration. Everyone has their own ideas about how it could have been distributed differently, both among fields of science and over the years. But there cannot be any question that this country has significantly boosted spending on research during this Administration. [See figures below.] The myths of downward trends in science spending are based on measures other than actual dollars spent. Patterns of U.S. science funding do show some disturbing trends, and they need to be fixed. But if we dwell only on those trends I believe we indirectly raise false expectations that future Administrations will be able to solve science funding problems simply by adding more funds to the pot. As always there will be winners and losers.

Earlier this year I was asked by the Harvard International Review to write an article on "International Aspects of Climate Change." The editors explained that they were looking for a "theoretical" paper, which is easier for me to write than one requiring any real knowledge of the topic. In studying possible frameworks for thinking about how nations must behave to address the very serious and difficult challenge of global warming, I came across a 2002 National Research Council survey called "The Drama of the Commons". The reference here is to an influential paper by biologist Garrett Hardin in 1968 in Science Magazine called "The Tragedy of the Commons." That term is now part of the policy vocabulary, and common resources scholarship has become an important area of social science research. The tragedy of the commons is the tendency of an unregulated resource (think of ocean fisheries) to become depleted as the result of rational choices made by individual users of the "commons". There are common resources, like fisheries, and common resource sinks for unwanted byproducts, like the atmosphere. Hardin's paper is fascinating, and should be mandatory reading by science policy students (it probably already is.) The commons studies give us insights into what must be done to keep the commons productive.

As I was writing the paper on climate change, it occurred to me that Sarewitz's view of science funding has some of the characteristics of a resource commons. The funds are relatively stable and predictable from year to year, and they are exploited through the actions of multiple stakeholders including Executive agencies, members of Congress and their staffs, lobbyists, individual and organized science activists, think tank advocates, and many others who seize on science symbols to make their own case for a piece of the common resource pie. While there is at least a management framework in the Executive Branch, of which my office and OMB are a part, that attempts to regulate the exploitation of this resource, there are no corresponding frameworks to limit the impact of the other stakeholders, including Congress. One result, of course is the growth of earmarking, which closely resembles the unregulated use of a common resource.

This is the right place to acknowledge and praise the actions taken by the AAAS this year to treat earmarks in a systematic and straightforward way in their budget analysis. Perhaps Kei Kuoizumi, who speaks next, will say something about this. Two years ago I challenged OMB

and AAAS to come together and work out a common approach to accounting for and reporting the effect of earmarks on the science budget. Last year OMB introduced an earmark website full of fascinating information. This year AAAS has made a useful study of the issue and has incorporated a good treatment in their reports. They estimate that Congressionally designated, performer specific R&D projects in 2008 total $4.5 billion, and concluded that "in a tight budget environment earmarks once again crowd out hoped-for increases in competitively awarded research programs."

These earmarks are not simply whims of Congress. They come as a direct result of members of the science community, contractors, and others advocating for their projects. Many are worthy – let us stipulate that they are ALL worthy. But is this the most effective use of our resource commons? What guarantees the result is the best for the American people, or is even, in some sense, sustainable? What guarantees that the most essential research ever gets done? Enlightened organizations representing large numbers of constituents here in Washington have made some efforts over the years to persuade their members that they need to advocate for broad programs, or for agency funding, and not for specific projects that seek to avoid review before receiving funds. They have not had much success. The jobs of many in this audience are part of a large and growing machinery aimed at bringing home the bacon for your organizations.

Earmarks are not the only aspect of the exploitation of the science funding commons. Various set-asides and incursions into the agency research missions have a similar effect. Like the SBIR tax on every agency's science budget that narrowly escaped a costly increase earlier this month, thanks to a floor action initiated by physicist-Congressman Vern Ehlers. Or the addition of new dimensions to program requirements related to education or outreach. The research commons is shrinking because of these incursions. Let's assume here too that they are all worthy. Most taxpayers look at these agency budgets – for NSF or the Department of Energy, for example – and assume the spending is for science. How is the science going to survive as the commons shrinks under these incursions?

I don't want to dwell at length on this problem, but it is very serious, and I think it helps to view it through the resource commons lens rather than as a problem of ethics. Curiously, Garrett Hardin's subtitle for his original "Tragedy of the Commons" paper is *"The population problem has no technical solution; it requires a fundamental extension of morality."* So he, at least thought the situation in extreme cases entailed moral considerations. Most social scientists who study these questions agree that commons must be managed under a consensual framework that regulates the behavior of the actors to avoid degradation of the resource.

During my tenure in Washington I have seen three remarkable issues around which consensus among stakeholders has sprung up with an almost religious fervor. The successful doubling of the NIH budget between 1998 and 2003, the successful establishment of the new area of "homeland security research", and the as yet unsuccessful introduction of a set of actions, including selected research increases, to bolster future national economic competitiveness. The lack of success of the latter is quite unusual given the very wide and intense support for it across parties and sectors. I have said enough about the process failure that led to this result, but it is one of the most serious pieces of unfinished policy business begun in this Administration.

There is no question that there is now a large and unhealthy imbalance among funds for various sectors of science, usually described as biomedical research versus physical science,

engineering, math and computer science. Federal support for the latter has languished for several decades. Now federal support for biomedical research has languished for half a decade. The budgets are still out of balance. We would certainly be better off today if the 109th Congress had passed its appropriations bills before going home. They would have begun to restore balance and start the building up of a technical workforce in fields badly needed for future progress in all parts of science and technology. This year, for the third year in a row, President Bush has proposed a path forward that aims to shrink the gap for critical fields where global competition is very strong.

Returning to the commons analogy, many other countries have forms of government that allow much stronger frameworks for managing the research commons. They have forms of central planning, regulation, and budget control that would never work in the U.S. I think our system is ultimately more creative and flexible, but it does permit digressions and distractions from policy goals. Although corruption, waste, and ignorance divert resources in some other countries, some of them at least have systems that prevent substantial deterioration of the commons of public resources by the random incursions of individual well-meaning actors.

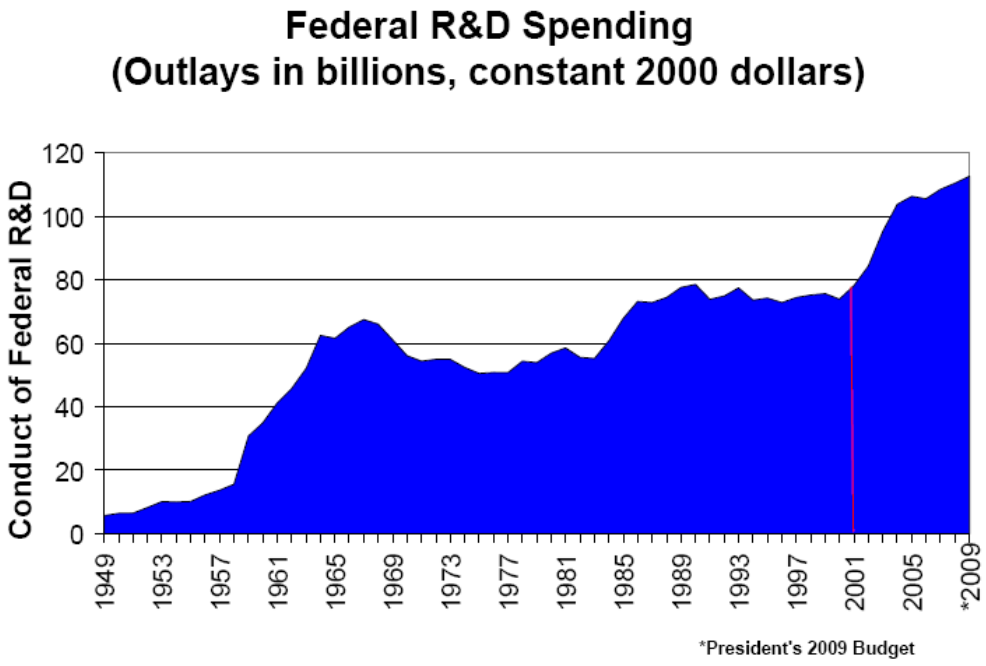
I think of the ACI and America COMPETES initiatives as unfinished business on an agenda that will continue to receive wide support because they address real and widely recognized problems. But maintaining that support will require continual effort by the organizations like the Council on Competitiveness and many others that have already worked so hard to make the case. The case has to be made over and over again as the political actors change.

There are other important challenges in our science coverage. Smaller agencies, like NIST, USGS, NOAA and research units within other departments whose main mission is not science, often provide services that are critical to many other departments. Appropriators for these agencies have little incentive for heeding the needs of these other stakeholders. Think of the Geological Survey, for example, which Google and all the rest of us rely upon for land imaging. The increasingly urgent problem of water management depends on USGS research. Earth imaging programs of all sorts will need to grow in the future and be sustained through stable management structures within stewardship agencies. The visibility of NIST has been increased because of its inclusion in the ACI, but it has yet to receive the kind of boost its research budget requires to maintain its part of the innovation infrastructure. Within the huge Department of Defense the basic research function has some of the characteristics of a small agency. DoD basic research funding has drifted since the end of the cold war, much to the detriment of university based engineering research. The good news for DoD research in the FY09 budget proposal is a dramatic shift of resources toward the 6.1 basic research category. The reconstruction of the basic research function in DoD will take years, and will only happen with constant support from the highest leadership levels. I give Secretary Gates much credit for encouraging and supporting this initiative, and hope his successors follow the same path. Finally while NIH is certainly not small (although some of its institutes are), its budget cannot remain flat much longer. It will need to increase in a predictable, sustainable way in the future if we are reap the value of our very substantial investment in biomedical research.

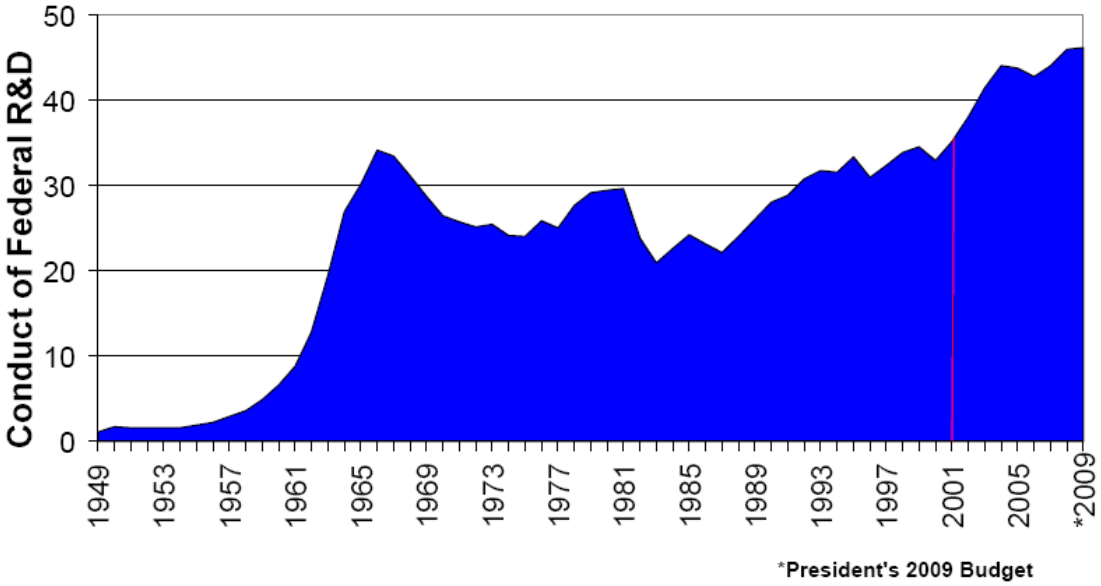
How are all these challenges to be overcome in a time of constrained budgets? In the immediate future, the best thing that could happen for U.S. science is for Congress actually to pass a budget for FY09 as part of its regular business this year. I would like to see a bill that

funds the President's request and finally launches a competitiveness initiative. The 2008 Omnibus bill seriously wounded U.S. interests in high energy physics and the international fusion energy project, ITER, and it weakened our long term prospects for competing successfully in a globalized technology intensive economy. That is the wrong signal to the American people, to the science and engineering communities, and to the world. The sooner Congress can pass bills moving us forward from this dreadful position, the better. As to the prospects for a supplemental budget that adjusts funding for FY08, the issue is rapidly becoming moot because two thirds of the year have passed already. Timely passage of FY09 budgets – which is after all what Congress is supposed to do – at this point would be the strongest bridge to the future.

I would like to thank AAAS for inviting me yet one more time to speak at this Forum, and for sponsoring so many efforts to capture the strength of U.S. science and engineering for service to our country.



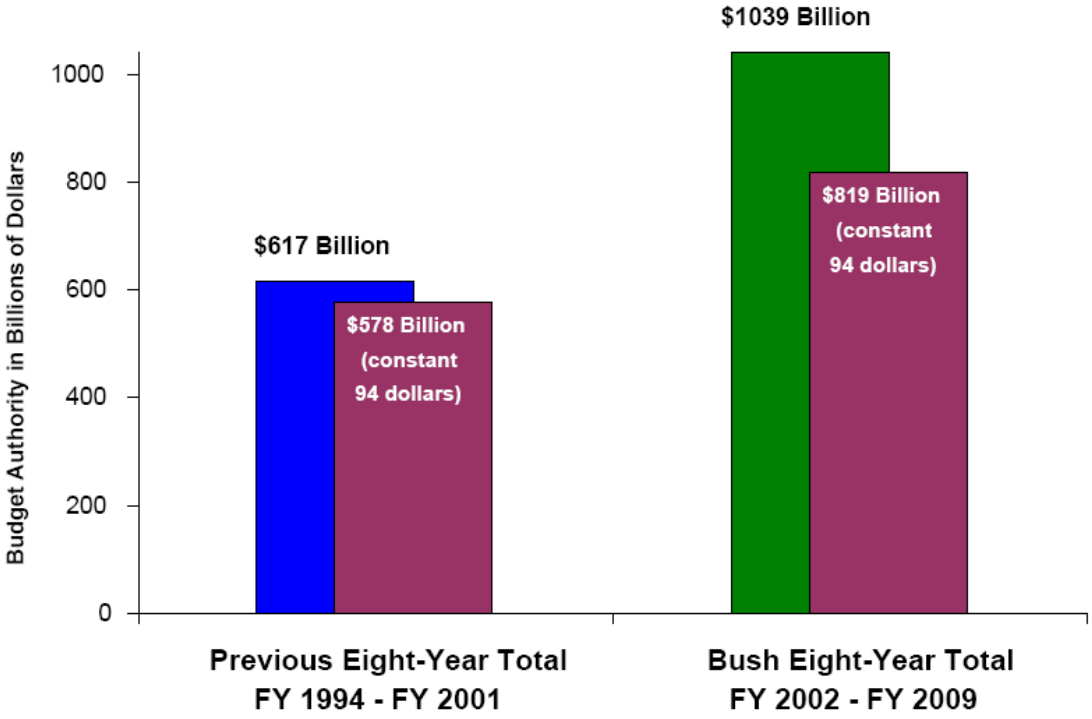
Federal Non-Defense R&D Spending
(Outlays in billions, constant 2000 dollars)



*President's 2009 Budget

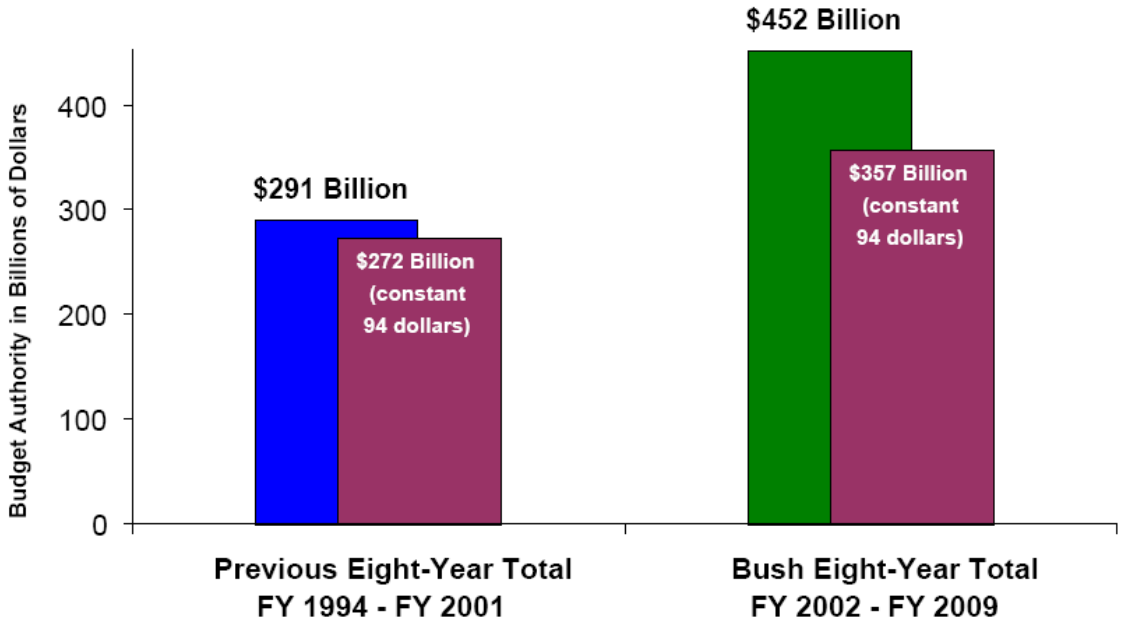
Federal Research and Development

42% More Real Investment



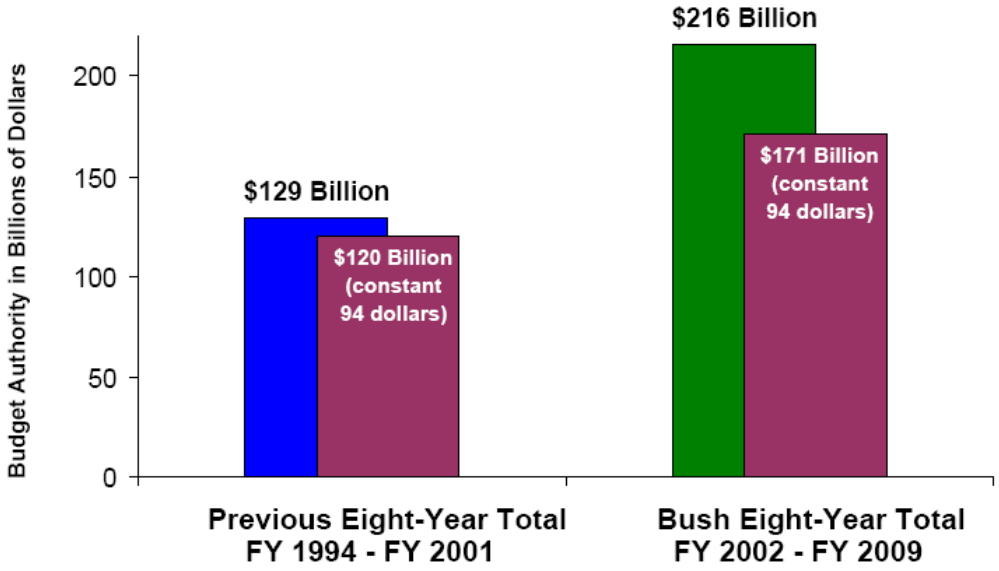
Civilian Research and Development

31% More Real Investment



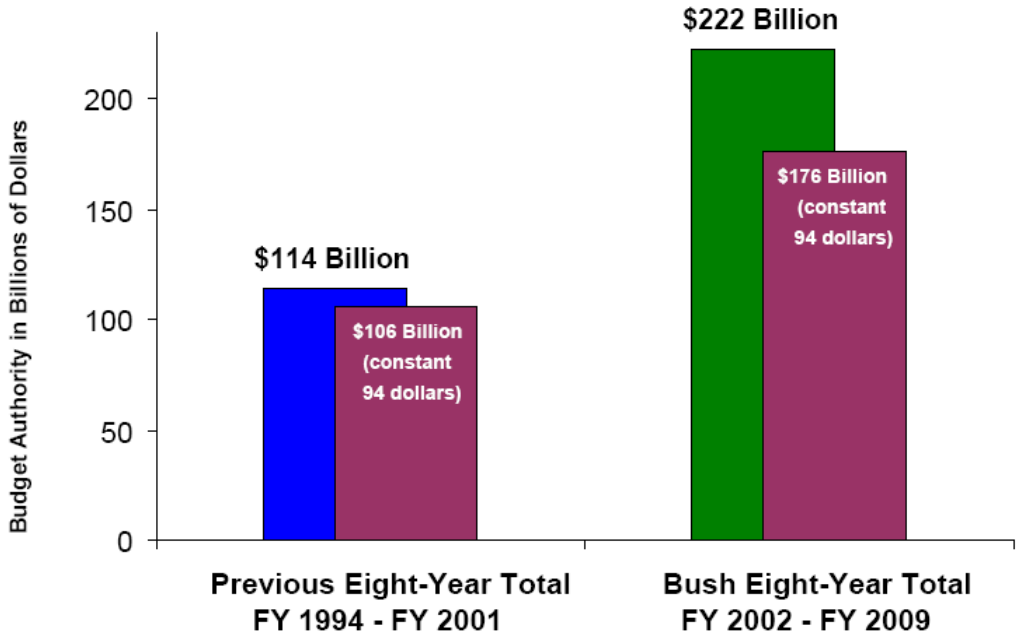
Basic Research

42% More Real Investment



National Institutes of Health

66% More Real Investment



National Science Foundation

36% More Real Investment