U.S. Funding of Japanese Priority Areas, and U.S. Priorities in R&D

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Planning for the Third S&T Basic Plan in Japan takes place in a time of dramatic expansion of the federal R&D investment in the United States, despite record government budget deficits and fiscal pressures from growing social insurance spending that threaten to choke off future investments. U.S. federal government funding of R&D has expanded dramatically this decade, totaling a projected $571 billion from 2001-2005. From a total of $91.5 billion in 2001, the federal investment has increased dramatically to a proposed (not yet enacted) total of $131 billion in 2005.[1] At purchasing power parities, the $571 billion U.S. investment far outpaces the $165 billion projected Japanese government investment during the same 2001-2005 time period.[2] Even excluding the enormous U.S. defense R&D investment, which is overwhelmingly devoted to weapons systems development on a scale unmatched by Japan and other countries, the nondefense R&D investment 2001-2005 totals $262 billion, again far exceeding the Japanese government investment.

In the past few years, the enormous increases necessary to reach the record $131 billion federal R&D budget for 2005 have gone overwhelmingly to defense weapons development and homeland security R&D. Until 2003, U.S. federal government spending on biomedical research through the National Institutes of Health (NIH) also increased dramatically as part of a five-year doubling plan for NIH between 1998 and 2003, but in 2004 and 2005 NIH is projected to receive only inflationary increases. Most other R&D programs have seen flat budgets, or at best increases keeping pace with inflation. Investment in this nondefense, non-biomedical R&D portfolio totals $124 billion in 2001-2005, and has remained just at inflationary levels during this time period.

Increases for biomedical research, defense, and homeland security have resulted in a turnaround in the federal R&D investment as a share of the U.S. GDP (Gross Domestic Product). U.S. policymakers have long lamented that the federal R&D/GDP ratio has declined steadily in recent decades, dipping below 1% in 1994. But after hitting a low of 0.75% in 2000, the federal R&D/GDP ratio has climbed upward and is projected to exceed 1% of GDP in 2005 again.[3] This ratio would put the United States government well ahead of the government R&D/GDP ratios of other nations, including Japan and the EU nations.

U.S. Investments in Japanese Priority Areas

Japan's 2nd S&T Basic Plan identified four priority areas for Japanese R&D investments: life sciences, information and communications technologies (ICT), environment, and nanotechnology. In order to facilitate comparisons between the United States and Japan, AAAS has, under subcontract from the Japanese government, performed a detailed analysis of U.S. federal R&D investments in these priority areas, matching the Japanese definitions of these

[1] AAAS R&D data, from *AAAS Report XXIX: Research and Development FY 2005*, April 2004. See Historical Tables. All years are U.S. government fiscal years (Oct 1- Sept. 30).
[2] $1 = 146 yen PPP.
[3] These figures are based on federal R&D budget data from AAAS compared against U.S. GDP figures from the *Budget of the U.S. Government FY 2005*. These ratios are substantially higher than the R&D/GDP ratios reported through other surveys such as the National Science Foundation and the OECD, although the trends are similar.

priority areas to U.S. budget decisions. The attached tables provide data on U.S. federal investments in these priorities by agency or program, and also by theme.

U.S. federal R&D investments in the four Japanese priority areas totaled $42 billion in the most recently completed fiscal year (2003), far outpacing Japanese investments in these areas (see Tables 1 through 4). As a share of the total U.S. federal R&D investment, these four priority areas account for 60 percent of the total (excluding weapons development funding), compared to 42 percent for Japan in the same year.[4] (In the U.S. case, there is overlap between the four priority areas, primarily between environment and the life sciences although eliminating overlap would reduce the U.S. total by less than $1 billion.) Total federal R&D investments in these areas would grow slightly to $42.9 billion in the proposed 2005 budget.

Clearly, the major reason for the U.S. outpacing Japanese investments is because of the enormous U.S. investments in biomedical research within the life sciences area. At $31.6 billion in 2003, the U.S. life sciences investment alone accounts for 45 percent of the federal R&D portfolio (excluding weapons development), of which biomedical research accounts for $28.2 billion. The sheer size of the biomedical research investment makes direct comparisons between the U.S. and any other nation (including Japan) difficult, and warrants an extended discussion of the U.S. biomedical research investment and its features.

Life Sciences

Biomedical and other human health-related research has long been a priority for the U.S. government, but in recent years the level of federal support for biomedical research has expanded dramatically to become the largest part of the federal nondefense R&D portfolio, especially in the five years between 1998 and 2003 when the U.S. government embarked on a (successful) campaign to double the budget of the National Institutes of Health (NIH), the dominant U.S. sponsor of biomedical research. Although estimates of other nations' biomedical research investments are imprecise, it is clear that the U.S. government spends at least ten times more on biomedical research than any other nation.[5]

Although life sciences is a broad term, Table 1 makes clear that the NIH investment in biomedical research (human-related life sciences with potential medical applications) clearly dominates U.S. spending in this area, especially when biomedical investments in the Departments of Defense and Veterans Affairs are also included. Investments in agricultural sciences or non-biomedical life sciences, while substantial at more than $2 billion and more than $1 billion, respectively, are dwarfed by the now $29 billion annual investment in biomedical research.

NIH is organized mostly around disease-specific lines, an organizational form unique to NIH. NIH is actually a federation of 26 major institutes, centers, and divisions (ICDs), with each ICD budget determined separately and with each ICD having its own administrative structure (see Table 5). Most of the ICDs are organized around diseases (cancer, heart disease, etc.) while the remainder are organized around specific topics or problems (nursing, health disparities, alternative medicine). Only a few ICDs cut across these disease or topic boundaries. It is important to note that because of these organizational characteristics, NIH funding of R&D is not organized by scientific discipline, nor by research performer or funding mechanism. Each ICD

[4] *AAAS Report XXIX: R&D FY 2005*, Table II-1. Total federal R&D excluding weapons development (DOD "6.4" through "6.7" and other appropriations) was $70.2 billion in 2003.
[5] Based on comparisons of government "health and environment" R&D investments in the OECD MSTI database.

selects its own mix of disciplines, funding mechanisms, or performers according to its own scientific needs.

The ICD budgets do not grow at the same rate; rather, NIH management and the U.S. Congress engage in priority setting. Between 1998 and 2005, the NIH budget grew by 110 percent, with doubling between 1998 and 2003 and two more years of slower growth (see Table 5). But only seven of the ICDs actually saw their budgets double between 1998 and 2003 (three new ICDs were created during this time) and only two more reached the doubling point by 2005. The greatest gain went to the National Institute of Allergy and Infectious Diseases (NIAID), primarily because NIAID became the home of biodefense research in the government in the aftermath of the September 2001 terrorist attacks and the fall 2001 anthrax postal attacks. Biodefense research became a high priority and thus the NIAID budget more than tripled during this time period. Similarly, the high priority assigned to the Human Genome Project led to large increases for the National Human Genome Research Institute (up 126 percent) and an increased emphasis on research infrastructure and research tools led to a large increase for the National Center for Research Resources (up 141 percent).

NIH also engages in priority setting in the ways it distributes its funds. During the doubling period 1998-2003, various funding mechanisms grew at different rates. The majority of NIH funding goes to Research Project Grants (RPGs), which are investigator-initiated, competitively awarded research grants awarded to external performers (mostly university faculty) through a peer-review process. Nearly all of these grants are multi-year projects with funding coming each year from NIH budgets. The average length of an RPG is almost three years. Between FY 1998 and 2005, funding for RPGs nearly doubled, increasing by 97 percent, or less than the growth in the NIH budget. During this time, the number of RPGs grew by only 39 percent, while the average dollar amount of an RPG increased by 25 percent. The RPG success rate (the number of funded proposals divided by the total number of proposals) is less than one third, currently 29 percent.

Other funding mechanisms grew faster than RPGs. The largest increase over six years was in R&D contracts, an increase of 233 percent between 1998 and 2005. R&D contracts usually demand specific deliverables with specified end dates on topics chosen by NIH. R&D contracts funding surged beginning in 2002 because much of the NIH biodefense effort is funded through the mechanism; this effort, unlike most of NIH's work, has well-defined technology goals and strict timelines. For a similar reason, funding for research centers increased 131 percent between 1998 and 2005; research centers are multi-year commitments to fund research on specific topics at external institutions (usually universities). The topics and centers are chosen by NIH, but then universities compete to win these centers. Again, the rapid expansion of biodefense research has led to an increased use of this mechanism.

NIH is so dominant that other agencies play niche roles in the biomedical research enterprise. Most of the Centers for Disease Control's (CDC) R&D is performed intramurally, as is all the R&D in the Department of Veterans Affairs which operates a network of research hospitals serving military veterans. DOD medical research awards competitively awarded R&D grants on selected topics, resulting in nearly all the awards going to universities and nonprofits.

Thus, the enormous U.S. life sciences investment is almost entirely a product of favored budgetary treatment given to NIH for biomedical research that has created a U.S. biomedical research enterprise unparalleled in the rest of the world, and unlikely to be duplicated anywhere else. Within this enterprise, competitively awarded R&D funds are the rule, with particular emphasis on investigator-initiated, peer-reviewed grants. But in recent years, the growth of biodefense research and other larger research projects have led to rapid increases in other funding mechanisms such as contracts and research centers which, although still competitively awarded, are more tightly linked to agency missions and to outcomes.

Information and Communications Technologies (ICT)

ICT R&D has been an explicit R&D priority area for the federal government dating back to the Clinton Administration. President Clinton, responding to a 1999 report from his President's Information Technology Advisory Committee (PITAC), reformulated a decade-old government information technology (IT) effort into the Networking and Information Technology Research and Development (NITRD) program. The NITRD program is now a multi-agency, coordinated R&D initiative authorized by law, as shown in Table 2. The Japanese ICT priority area definitions match closely with NITRD programs, so the U.S. investments depicted here are the NITRD program in its entirety.

Although the 1999 PITAC recommendations envisioned steadily increasing investments exceeding $2.6 billion a year by 2004, actual NITRD funding has stalled at roughly $2 billion a year for the past four years, victim of fiscal pressures affecting all nondefense R&D funding agencies and the deployment of additional resources elsewhere.

Recently, there has been a renewed push for increasing ICT R&D funding, motivated in part by advances in Japanese supercomputing capabilities. The unveiling of the Japanese Earth Simulator in 2002, taking over the U.S. lead in civilian research supercomputing, led to worries that the U.S. was about to lose its crucial lead not only in research supercomputing but the wider IT field as well. Policy responses have been slow in formulation, but in 2004 there has been renewed interest among policymakers in this field. Recent congressional interest has focused on the area of high-end research computing, one of the focus areas within the NITRD. Two bills are now before the U.S. House of Representatives to authorize new efforts in R&D in this area, one for the Department of Energy (DOE, the traditional home of research computing R&D) to carry out a high-end computing R&D program and one for the entire government to establish revised research goals for high-end computing and to promote access to government computing capabilities by the scientific community.[6] Both bills are unlikely to be enacted before 2005 at the earliest, and are authorization bills rather than budget bills so they will not provide any additional funds.

Environment

The environment, broadly defined, has always been a high priority for the U.S. federal R&D portfolio but the federal investment has been under pressure in recent years. After exceeding $7.5 billion a year from 2002 through 2004, the latest federal budget proposes to reduce the investment down to $7.4 billion in 2005 (see Table 3). The environmental R&D portfolio is the most difficult to define of the four priority areas because of both the vagueness of the Japanese definition and the scattered nature of the U.S. investment. The U.S. investment in 'natural resources and environment' R&D is only $2 billion a year, but including environment-related R&D funded under other national missions such as space, health, and energy brings the broader U.S. environmental R&D portfolio above $7 billion. As Table 3 shows, the federal R&D portfolio is scattered among a dozen federal agencies, with no formal coordinating mechanism to integrate these investments. There is a formal budget process and coordinating mechanism for a subset of

[6] The bills are HR 4516, the Department of Energy High-End Computing Revitalization Act of 2004, and HR 4218, Amendment to the 1991 High-End Computing Act.

these investments concerned with global climate change under the auspices of the Climate Change Science Program (formerly the Global Change Research Program), but this subset amounts to less than $2 billion of the total.

Nanotechnology

Since the announcement of the National Nanotechnology Initiative (NNI) in the late days of the Clinton Administration, U.S. investment in this priority areas has expanded dramatically (see Table 4). The federal investment doubled in just three years between 2001 and 2004, and now approaches $1 billion a year. Along the way, what started out as a scattered collection of federal investments has become a full-fledged multi-agency initiative. President Bush in December 2003 signed into law a nanotechnology authorization law that created a formal advisory structure, recommendations for studying the social and ethical implications of nanotechnology, and a formal interagency coordinating process embodied in an interagency coordinating committee. The initiative itself is evolving from applied research toward a more basic research-oriented effort and the terminology is shifting away from 'nanotechnology' to 'nanoscale science and engineering' in order to emphasize the multidisciplinary, long-term thinking behind the federal effort. In fact, despite the popular view that nanotechnology may involve the creation of molecular self-assemblers and other nanoscale devices, nanoscale machines are NOT part of the NNI. Instead, the NNI research agenda focuses on research at the nanoscale on a wide variety of topics such as nanoscale phenomena, nanoscale manufacturing, nano-biosystems and medicine, nanoscale detection systems, and even nanoscale agriculture.

Even in tough budgetary conditions, the Bush Administration and the U.S. Congress have supported increased funding for NNI, but funding has already fallen short of authorized levels. The 2003 nanotechnology law authorized funding for most of the NNI funding agencies (except DOD and HHS) but the 2005 request falls nearly $200 million short of the authorized funding level, demonstrating that the dramatically increased investments envisioned in the law will be difficult to achieve in the current U.S. fiscal environment, and that nanotechnology is becoming a 'mature' priority area with relatively stable priorities and funding.

Other Focus Areas

For three of the other four focus areas (social infrastructure, manufacturing and energy) as defined by the Japanese government, corresponding U.S. investments are relatively small, totaling just $4 billion in 2003, with flat or declining funding (see Figure 1). The fourth focus area of frontiers, which includes the space programs of both nations, is a special case for the federal government. The U.S. space program has traditionally been a high priority for the federal R&D investment. At nearly $10 billion a year, the U.S. investment in space-related R&D dwarfs investments in other nations and is sustained not only by the International Space Station, planetary exploration, and Space Shuttle missions but also by space-based observations of the environment and space-based life sciences research that also feeds into the priority areas of environment and life sciences. Combined with another $1.4 billion in R&D investments in other frontiers of the oceans, atmosphere, the poles, and astronomy, the federal R&D investment of $11.4 billion in frontiers R&D amounts to 16 percent of the non-weapons R&D portfolio in 2003. The frontiers portfolio is the second-largest U.S. R&D investment among the 8 Japanese priority and focus area (again, these percentages reflect double counting of some programs). By comparison, none of the other three focus areas (social infrastructure, manufacturing, and energy) account for more than 3 percent of the non-weapons federal R&D portfolio, in contrast to their more prominent place in the Japanese government R&D portfolio.

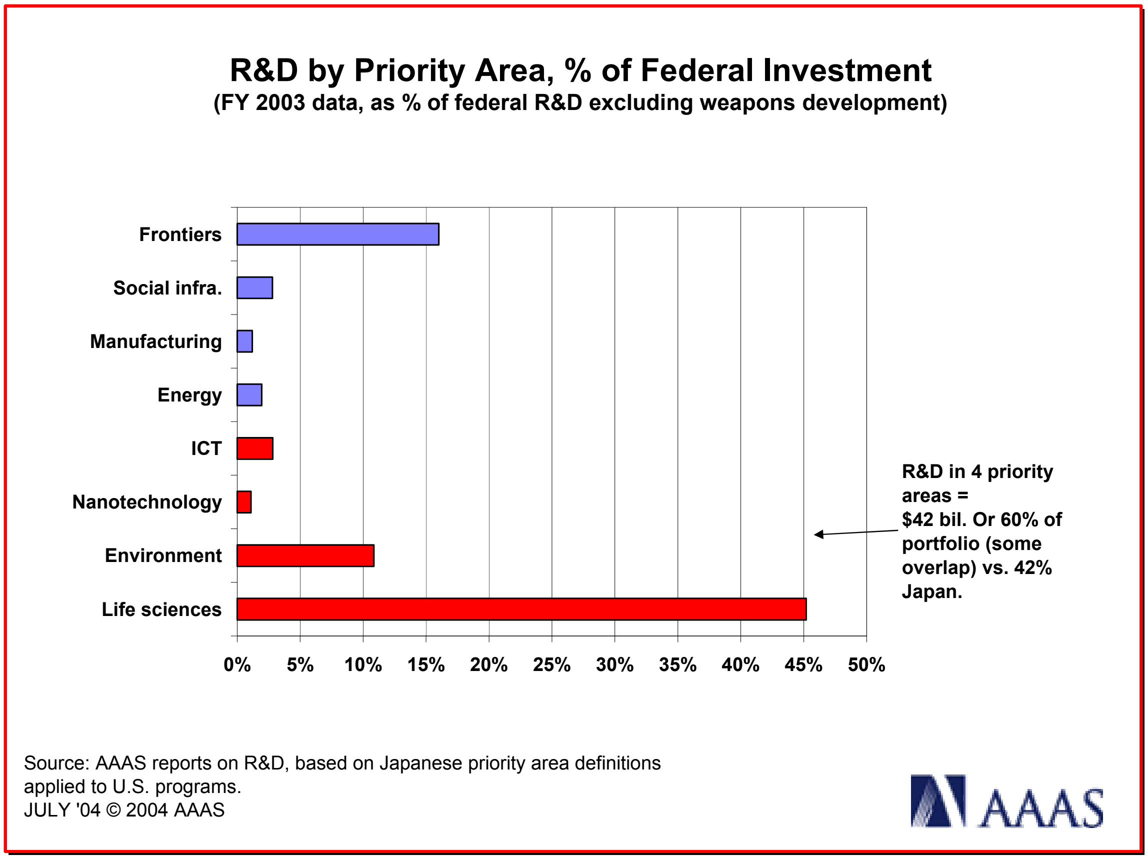

Figure 1.

Emerging Priority Areas: Homeland Security

Unlike at the turn of the century, when NITRD and nanotechnology emerged as major new priority areas for the federal R&D investment, there are no major R&D priorities on the horizon at mid-decade although ideas such as neuroscience and social sciences have been suggested. Instead, in a time of increasing fiscal restraint, there has been a major shift in federal R&D resources to homeland security. Since the September 2001 terrorist attacks and the fall 2001 anthrax letters, there has been a dramatic expansion of federal investments in homeland security R&D.

Despite the creation in 2003 of a new Department of Homeland Security (DHS), homeland security R&D is an interagency effort and in fact the majority of it is funded outside DHS. The concept of homeland security itself is still new, and is an outgrowth of longstanding multi-agency federal investments in counter-terrorism programs given new urgency and new direction after the fall 2001 terrorist attacks. Until 2001, counter-terrorism R&D was an effort of about $500 million a year with the majority of support coming from the Department of Defense (DOD), because it was assumed that U.S. military forces abroad were the most at risk from terrorist attacks. After the September 11 and anthrax attacks, this thinking changed dramatically and, as a consequence, homeland security as an effort to prevent, minimize, and recover from terrorist attacks within the United States became a new concept and mission for the federal government. Ultimately, this newly-articulated mission found expression in a new cabinet-level federal department to consolidate many but not all federal counter-terrorism programs, and a dramatic expansion of federal homeland security spending both inside and outside the new DHS.

From $1.5 billion in 2002, mostly new funding enacted in the immediate aftermath of the fall 2001 terrorist attacks, the R&D portfolio more than doubled to $3.3 billion in 2003, primarily because of a $1.5 billion increase in the National Institutes of Health (NIH) bioterrorism R&D portfolio.[7] The portfolio grew again to $3.6 billion in 2004, driven by substantial increases in the new DHS. In 2005, HS R&D would move past $4 billion with a 15.9 percent increase to $4.2 billion because of continuing growth in DHS and substantial new investments in the U.S. Department of Agriculture (USDA).

The largest single agency funding source would be NIH for its support of biodefense research. NIH's dominance of the portfolio indicates the biodefense research is by far the most important new priority within the field of homeland security. NIH had supported bioterrorism-related research for years, but its research portfolio became a high priority after the fall 2001 postal anthrax attacks. NIH identifies $1.8 billion for biodefense R&D in 2005, up 4.5 percent from this year. As recently as two years ago (2002), the NIH investment was only $162 million. Most NIH biodefense R&D is funded by the National Institute of Allergy and Infectious Diseases (NIAID) and is a mix of basic research aimed at understanding the basic biology of potential bioterror threats, applied research toward vaccines and countermeasures against bioterror threats, and development of candidate vaccines and countermeasures.

Outside of biodefense research, however, the federal homeland security R&D effort has been heavily concentrated in development, and even within development toward the later-stage testing and evaluation of potential new technologies originating in the military arena or in the private sector. In this regard, much of homeland security R&D resembles the weapons systems development traditionally supported by DOD. The federal government has so far funded relatively little research in areas outside of biodefense, although the goal is eventually to fund increasing amounts of basic and applied research to identify long-term terrorist threats and to develop tools for threat assessments, threat rankings, and other topics.

At mid-decade, another emerging area of research is the set of energy R&D topics centered around a possible hydrogen economy of the future, but this area is unlikely to see expanded federal investments. The Bush Administration has made the eventual attainment of a hydrogen economy as cornerstone of its energy and climate change policy, and has called for expanded investments in hydrogen power research, fuel cells technology, and hydrogen production and distribution R&D.[8] At the same time, the Bush Administration has also called for increased investments in coal and nuclear energy R&D. But these proposals for increased investments are offset by proposals to reduce dramatically federal support for other energy R&D areas such as solar and renewable energy, energy conservation, and fossil fuels other than coal. So far, the U.S. Congress has balked at these proposals and preserved the current priorities in the U.S. energy R&D portfolio; if Senator John Kerry wins the presidency, then hydrogen-related R&D is likely to receive even less emphasis.

[7] AAAS, "Bush Administration Seeks $4.2 Billion for Homeland Security R&D in FY 2005," Homeland Security R&D in the FY 2005 Budget, 12 May 2004. (www.aaas.org/spp/rd/hs05p.htm)

[8] See Spencer Abraham (U.S. Secretary of Energy), "The Bush Administration's Approach to Climate Change," *Science*, 30 July 2004, pp 616-617.

Impacts of Funding Trends on the Federal Research Portfolio

Despite efforts by advocates for physical sciences, engineering, and the other sciences, life sciences research (almost entirely biomedical research) continues to dominate the federal research portfolio.[9] The disproportionate impact of NIH on federal research, already apparent in the life sciences priority area, is also apparent in the wide and growing disparity in federal funding between the biomedical sciences that NIH supports and all other sciences. Figure 2 shows trends in federal research by science and engineering discipline over the past three decades. Federal support of the life sciences (nearly 90 percent of which comes from NIH) has grown steadily over the past three decades and accelerated its growth beginning in 1998 with the start of the NIH doubling campaign. Because of continuing growth in the NIH budget, federal support for the life sciences now makes up the majority (54 percent) of the federal research portfolio.

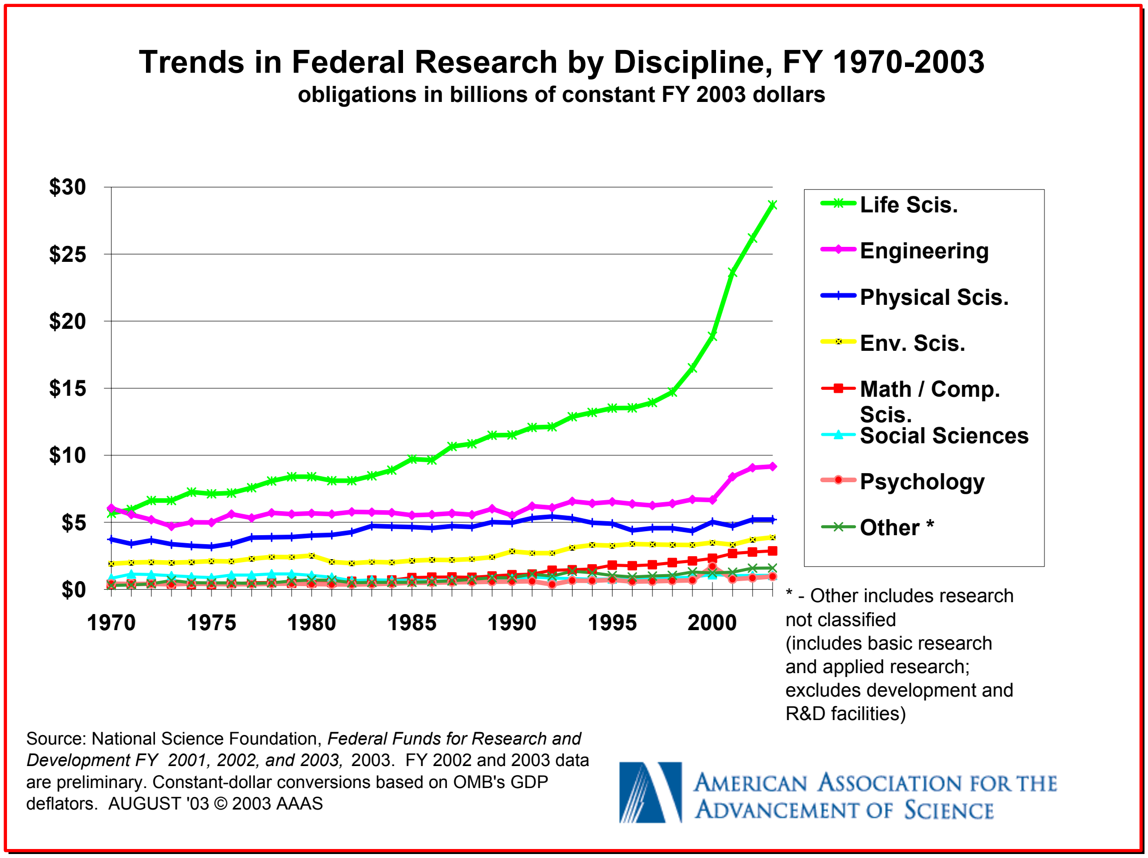

Figure 2.

Meanwhile, federal support for all the other sciences has mostly stagnated or shown just modest increases with the exception of the computer sciences. Even modest growth in federal support for some of these disciplines stands in sharp contrast to sustained growth in the federal budget, the U.S. economy, and federal R&D over the past three decades. These flat or slightly increasing trends also mask the shifts in research funding within disciplines. The growth of new areas such as nanotechnology, IT research, and bioengineering within disciplines has, in the absence of new funds, displaced federal funding for more traditional areas within disciplines.

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[9] This section refers to federal investments in basic and applied research, and excludes investments in development and R&D facilities.

Federal research, despite the growth in biomedical research support, is now shrinking as a share of the federal R&D portfolio, in contrast to the Japanese situation. Because of dramatic recent growth in defense weapons development and homeland security R&D (mostly in development), both basic and applied research make up smaller shares of the R&D portfolio than at the turn of the century. In 2000, with defense development funding in retreat in the post-Cold War era, total federal research surpassed development funding to make up 47.6 percent of the federal R&D portfolio compared to 49.9 percent for development (the remainder was for R&D facilities).[10] But the trend toward increasing shares for research has reversed in this decade and federal research is now just 42.2 percent of the portfolio in 2005 (proposed) while development is the majority of the R&D portfolio with 54.1 percent. The strategy of the U.S. military calls for sustained development investments over the next several years; combined with likely restraints on nondefense R&D spending, the share of research in the U.S. R&D portfolio is likely to continue to decline over the next few years. By contrast, in Japan the research share of the R&D portfolio is about 60 percent and increasing.

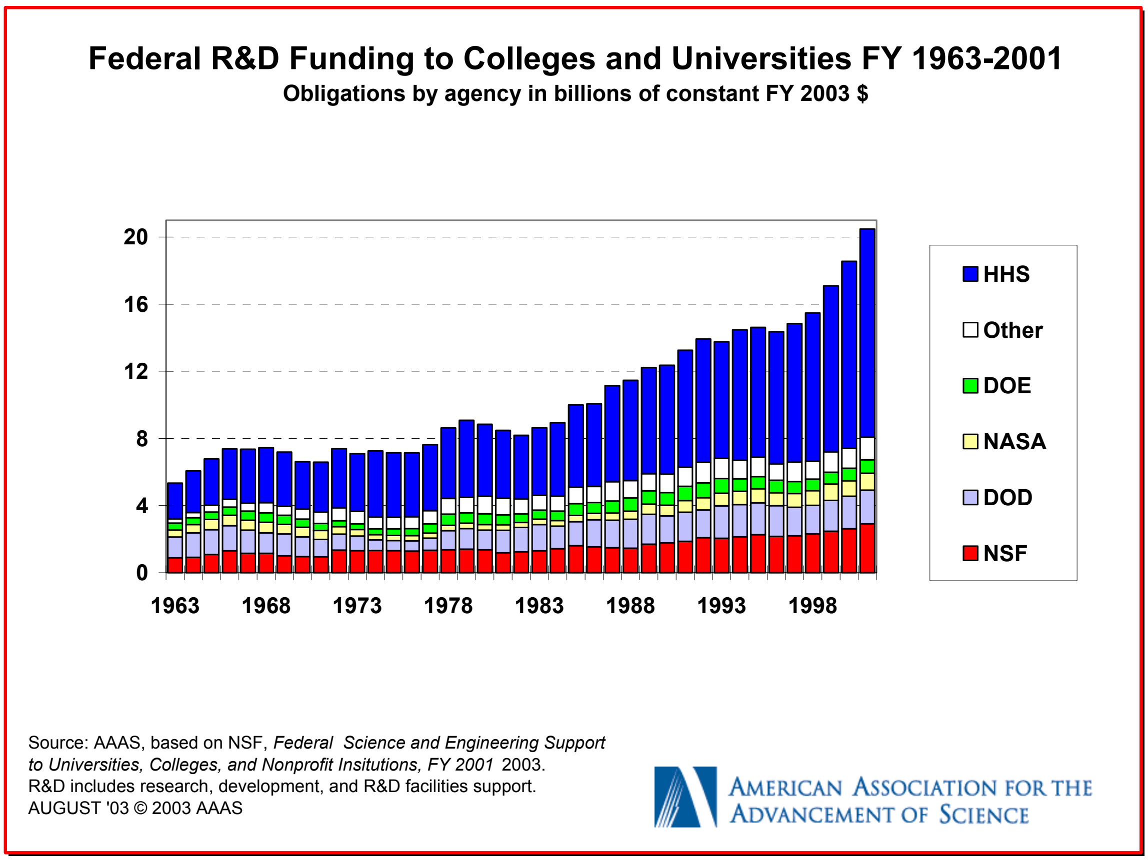

Figure 3.

This federal government shift toward development is matched by U.S. industry. Through the 1990s and into this decade, U.S. industry funding of development has grown as a share of all industry R&D, from 68 percent at the beginning of the 1990s to 73 percent in the latest year (2003). While applied research in industry has held its own, U.S. industry support of basic research has fallen from more than 7 percent of the industry portfolio to 5 percent over the past

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[10] *AAAS Report XXIX: R&D FY 2005*, Table I-5 and Historical Tables.

decade. So although earlier data showed that both U.S. industry and government were increasing their ratios of basic and applied research support through 2000 or so, these trends have reversed in both the government and private sector and are likely to decline further over the next few years.

Competitively Awarded R&D Funds

Within this shrinking share for federal research, however, the total dollar amount of research funding has grown and it appears that competitive research funding also showed steady growth, but growth could stall or even reverse in the future. There are no reliable figures on what proportion of federal R&D or research funds are competitively awarded, so it is necessary to use proxy measures. The most common proxy measure is federal R&D support to colleges and universities, for two reasons: nearly all federal R&D support to colleges and universities is competitively awarded (except for some agricultural formula funds and R&D earmarks), and colleges and universities win the vast majority of all competitively awarded R&D funds (the remainder goes mostly to nonprofit institutions).[11]

Figure 3 shows that even after adjusting for inflation, federal R&D to universities has surged over the past decade to over $20 billion a year, driven mostly by growth in the NIH budget. Growth in NIH translates directly to growth in competitive funds, because NIH consistently awards more than 80 percent of its budget competitively; for NSF, the ratio is even higher.[12] NIH and NSF are the two largest supporters of federal university R&D; because their R&D budgets have grown faster over the past decade than most other R&D funding agencies, it is not surprising that university R&D and therefore competitively awarded R&D has grown at a rapid pace. In the absence of true measures of competitively awarded R&D, tracking the NIH, NSF, and DOD basic research budgets (which together account for nearly 85 percent of federal university R&D support) is the best way to monitor current and future developments in U.S. competitively awarded R&D. Given slowing growth in NIH, NSF, and DOD basic research in the latest budget proposal and in budget projections, the pool of funds for competitively awarded research grants may flatten out or even shrink in 2005 or the next few years; such a slowdown could have a major impact on U.S. colleges and universities, which collectively rely on federal funds (nearly all competitively awarded) to finance 58 percent of their total R&D performance.

Future U.S. Federal R&D Investments

The U.S. government, unlike Japan's, does not engage in comprehensive forward-looking S&T planning, and does not publish future-oriented R&D budget plans. U.S. federal budgets are decided one year at a time, and plans or authorizations that purport to look at future budgets are only guidelines to be followed or discarded every year. Even authorizations that are signed into law such as the nanotechnology law of December 2003 provide only funding guidelines, and budgets usually fall short of authorizations. The only successful future-oriented budget plan in recent years was the NIH doubling effort, and that plan was never official; it was a political promise that never resulted in an authorization law or a planning document but was nevertheless completed. On the other hand, a similar five-year NSF doubling effort was actually signed into law as an authorization but budgets fell short of the plan in the very first year.

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[11] The best estimate for university R&D earmarks is about $1.9 billion in recent years (Chronicle of Higher Education). Formula agricultural R&D funds total about $300 million a year in recent years.
[12] AAAS estimate based on analysis of NSF and NIH budget documents.

Nevertheless, U.S. policymakers do have to make some plans for the future as they examine the future consequences of present budget policies. In particular, the executive branch and congressional budget committees are required to examine the five-year implications of their budget decisions and proposals. The latest federal budget projections to 2009 show that federal R&D investments in the second half of this decade will be severely constrained by other commitments and the U.S. budget deficit, and that even the high priority areas of national defense and homeland security will face harsh competition for resources.

The AAAS analysis of the latest Bush Administration outyear projections reveals that the Bush budget would cut R&D funding for all but three (out of 24) federal agencies over five years, and that the steepest cuts would fall in 2006 after this year's elections.[13] R&D funding increases would be concentrated in the three high priority areas of national defense, homeland security, and the space program. All other R&D programs would see their funding decline over the next five years, with even modest increases in 2005 reversed the next year and remaining below current levels after that.

For defense R&D, recent trends of large increases would continue but at a more moderate pace than in recent years. Defense R&D is at an all-time inflation-adjusted high of $70.5 billion this year (2004); the Administration budget plan calls for continuing increases in DOD and other defense-related R&D up to $77 billion by FY 2009, but would cut DOD's support of basic and applied research substantially.

In nondefense R&D, projected cuts would reverse the gains of the last several years. The NIH budget doubled between 1998 and 2003, but modest increases enacted in 2004 and proposed for 2005 would see the NIH investment level off, before planned cuts take hold that would reverse NIH's budget trajectory. Similarly, agencies such as NSF, DOE's nondefense programs, and USDA have all won increases in the last several years, but they would be reversed by the projected cuts. Only the newly created DHS and NASA would be immune from these trends, though even NASA's proposed increases would be insufficient to pay for ambitious plans to return humans to the moon and resume construction of the Space Station, requiring offsetting cuts in NASA's other program areas.

Although all budget projections are inaccurate because they are adjusted each year for changing conditions and priorities, it appears clear that the increases of recent years have come to an end. The federal government will run a record-setting budget deficit of about $440 billion this year, nearly one-fifth of the total federal budget. Regardless of the outcome of November's presidential election, the next U.S. President will face a deteriorating federal deficit situation, growing social insurance and medical insurance expenditures, and multi-billion dollar defense and homeland security commitments. The choices for U.S. policymakers will only become more difficult in the coming few years even if the U.S. economy grows strongly. Thus, it is highly unlikely that federal R&D investments in the next five years will match the funding profile of the past five.

Conclusions

Although the U.S. federal R&D investment has expanded dramatically in the most recent five years and new priority areas have gained attention and funding, the prospects for the next five years do not look bright. Past budget growth has depended boosts in funding for weapons

[13] "Bush Proposes to Cut Nondefense R&D Over the Next Five Years to Reduce Deficit," AAAS Analysis of the Outyear Projections for R&D in the FY 2005 Budget, 22 April 2004 (www.aaas.org/spp/rd/proj05p.htm)

development and homeland security R&D; in a constrained fiscal environment, growth in U.S. funding for all other R&D has stagnated recently and the outlook is for declining funding in the next few years. In the four Japanese priority areas, there has been strong growth in life sciences and nanotechnology along with flat funding for ICT and environment R&D. Among U.S. priorities, the new priority area of nanotechnology has received increased funding but older priorities such as IT and the environment/climate change have seen their funding stall. No new priorities have emerged to take their place with the possible exception of homeland security. But even with homeland security, R&D investments have been heavily development-oriented with the exception of biodefense, one area where new basic and applied *research* investments are taking place. The recent emphasis on development for defense and homeland security has resulted in a shrinking share of research within the federal R&D portfolio, a reversal of historical trends; the research share is likely to continue to shrink given the latest federal budget projections. The one bright spot has been continuing growth in federal research funding and competitive research funding driven by NIH budget growth, but even this growth has slowed recently and may even reverse in the near future.

Table 1. U.S. Federal R&D Investments in Life Sciences

Table 1. U.S. Federal R&D in Priority Areas, Historical

Life Sciences

(budget authority in millions of current dollars, by federal agency)

	$ (millions)														
	FY 1991 Actual	FY 1992 Actual	FY 1993 Actual	FY 1994 Actual	FY 1995 Actual	FY 1996 Actual	FY 1997 Actual	FY 1998 Actual	FY 1999 Actual	FY 2000 Actual	FY 2001 Actual	FY 2002 Actual	FY 2003 Actual	FY 2004 Estimate	**FY 2005 Budget**
National Institutes of Health	8,977	9,624	9,891	10,474	10,762	11,425	12,217	13,110	14,995	17,234	19,807	22,714	26,398	27,220	**27,923**
Centers for Disease Control	113	147	163	207	318	297	323	406	433	470	544	521	564	521	**530**
Department of Veterans Affairs	224	250	253	277	263	263	588	587	644	645	719	756	817	820	**770**
Department of Defense	0	0	0	0	0	0	0	0	38	295	432	464	458	486	**72**
U.S. Department of Agriculture	1,391	1,519	1,467	1,528	1,487	1,488	1,556	1,561	1,645	1,776	2,181	2,112	2,343	2,240	**2,163**
National Science Foundation	255	274	271	288	301	304	324	356	392	418	486	510	570	587	**600**
Department of Energy	360	346	332	381	403	393	374	391	422	422	514	554	494	590	**502**
TOTAL Life Sciences	11,321	12,161	12,376	13,154	13,534	14,170	15,382	16,411	18,569	21,260	24,683	27,631	31,643	32,464	**32,559**
by Theme:															
Biomedical research	*9,315*	*10,021*	*10,306*	*10,957*	*11,343*	*11,985*	*13,128*	*14,103*	*16,110*	*18,644*	*21,502*	*24,455*	*28,237*	*29,047*	***29,295***
Agricultural sciences	*1,391*	*1,519*	*1,467*	*1,528*	*1,487*	*1,488*	*1,556*	*1,561*	*1,645*	*1,776*	*2,181*	*2,112*	*2,343*	*2,240*	***2,163***
Non-medical biology research	*615*	*621*	*603*	*669*	*704*	*697*	*698*	*747*	*814*	*840*	*1,000*	*1,064*	*1,064*	*1,177*	***1,102***
Total	*11,321*	*12,161*	*12,376*	*13,154*	*13,534*	*14,170*	*15,382*	*16,411*	*18,569*	*21,260*	*24,683*	*27,631*	*31,643*	*32,464*	***32,559***

Source: AAAS, based on OMB data for R&D in the FY 2005 Budget,
agency budget documents, and information from agency budget offices.
Figures are rounded to the nearest million. Changes calculated from unrounded figures.
All years include regular and supplemental (emergency) appropriations.
FY 2004 figures represent latest estimates of most recent fiscal year.
FY 2005 figures represent latest estimates of R&D in FY 2005 budget request.
U.S. fiscal year is from October to September.
Life Sciences: AAAS compilation of R&D programs specifically focused on human health,
including biomedical research, human biology, and medical technology.
Also includes non-human life sciences such as agricultural sciences, basic biology,
and ecological science. Excludes space-based microgravity research (see Frontiers).

Table 2. U.S. Federal R&D in Priority Areas
Networking and Information Technology
(budget authority in millions of current dollars, by federal agency)

	$ (millions)														
	FY 1991 Actual	FY 1992 Actual	FY 1993 Actual	FY 1994 Actual	FY 1995 Actual	FY 1996 Actual	FY 1997 Actual	FY 1998 Actual	FY 1999 Actual	FY 2000 Actual	FY 2001 Actual	FY 2002 Actual	FY 2003 Actual	FY 2004 Estimate	**FY 2005 Budget**
Department of Commerce	* *	* *	12	29	32	30	31	34	25	36	39	43	26	26	**33**
Department of Defense	* *	* *	319	339	384	342	334	357	168	286	348	306	296	252	**226**
Department of Energy	* *	* *	101	122	113	110	119	129	610	338	475	313	308	344	**354**
Environmental Protection Agency	* *	* *	7	8	13	9	6	5	4	4	4	2	2	4	**4**
Dept. of Health and Human Services	* *	* *	46	58	69	83	92	97	111	191	244	309	376	368	**371**
National Aeronautics & Space Admin.	* *	* *	82	113	131	127	114	128	93	174	177	181	213	275	**259**
National Science Foundation	* *	* *	225	267	297	291	280	284	301	517	641	676	743	754	**761**
Other *	* *	* *	2	2	0	51	33	34	0	0	0	0	0	0	**0**
TOTAL Networking and IT R&D	489	655	795	938	1,038	1,043	1,009	1,070	1,312	1,546	1,928	1,830	1,964	2,023	**2,008**
by Program Area:															
High End Computing Infrastructure	* *	* *	*540*	*523*	*528*	*451*	*446*	*462*	*504*	*529*	*657*	*517*	* *	* *	* *
High End Computing Res. And Dev.	* *	* *	***	***	***	***	***	***	***	*209*	*250*	*272*	* *	* *	* *
Human Computer Interaction and Info.	* *	* *	^^	*156*	*240*	*188*	*240*	*280*	^	*230*	*273*	*308*	* *	* *	* *
Large Scale Networking	* *	* *	*114*	*142*	*164*	*284*	*253*	*255*	*291*	*300*	*322*	*334*	* *	* *	* *
Software Design and Productivity	* *	* *	^^	^^	^^	^^	^^	^^	^	*99*	*151*	*182*	* *	* *	* *
High Confidence Software and Systems	* *	* *	^^	^^	^^	*30*	*30*	*33*	^	*92*	*163*	*132*	* *	* *	* *
Social, Economic and Workforce	* *	* *	*140*	*117*	*106*	*90*	*41*	*39*	^	*85*	*112*	*85*	* *	* *	* *
Other ^	* *	* *	*0*	*0*	*0*	*0*	*0*	*0*	*517*	*0*	*0*	*0*	* *	* *	* *
Total	*489*	*655*	*795*	*938*	*1,038*	*1,043*	*1,009*	*1,070*	*1,312*	*1,543*	*1,928*	*1,830*	*1,964*	*2,023*	***2,008***

Source: U.S. National Coordination Office for Information Technology Research and Development.
Figures are rounded to the nearest million. Changes calculated from unrounded figures.
All years include regular and supplemental (emergency) appropriations.
* - Includes Department of Education and Department of Veterans Affairs.
** - Agency or program details not available.
*** This category was included in High End Computing Infrastructure until FY 1999.
^ Full data not available in FY 1999; most categories included in "Other" for that year.
^^ No funding in this category for that year.
FY 2004 figures represent latest estimates of most recent fiscal year.
FY 2005 figures represent latest estimates of R&D in FY 2005 budget request.
U.S. fiscal year is from October to September.
Networking and Information Technology: Federal agency programs in the multi-agency Networking and Information Technology R&D (NITRD) initiative and predecessor initiatives (IT2, HPCC).

Table 3. U.S. Federal R&D in Priority Areas, Historical
Environment
(budget authority in millions of current dollars, by federal agency)

	$ (millions)					
	FY 2000 Actual	FY 2001 Actual	FY 2002 Actual	FY 2003 Actual	FY 2004 Estimate	**FY 2005 Budget**
National Aeronautics and Space Admin.	1,690	1,762	1,628	1,717	1,613	**1,485**
Department of Energy	1,499	1,743	1,840	1,587	1,703	**1,528**
National Science Foundation	879	990	1,062	1,181	1,250	**1,279**
Environmental Protection Agency	558	562	592	567	616	**572**
Department of Defense	399	431	400	487	542	**514**
Department of Commerce - NOAA	643	561	677	663	617	**610**
Department of the Interior	618	603	623	643	675	**648**
U.S. Department of Agriculture	405	466	504	532	541	**525**
National Institutes of Health	60	63	81	84	78	**80**
Department of Transportation	39	44	68	76	54	**51**
Smithsonian Institution	14	40	40	41	42	**42**
Corps of Engineers	48	27	27	21	21	**21**
TOTAL Environment	6,853	7,293	7,541	7,600	7,752	**7,355**

Source: AAAS, based on OMB data for R&D in the FY 2005 Budget and previous years, agency budget documents, and information from agency budget offices.
Figures are rounded to the nearest million. Changes calculated from unrounded figures.
All years include regular and supplemental (emergency) appropriations.
FY 2004 figures represent latest estimates of most recent fiscal year.
FY 2005 figures represent latest estimates of R&D in FY 2005 budget request.
U.S. fiscal year is from October to September.
Environment: AAAS compilation of R&D programs focused on study of the natural environment, including space-based observation of the earth environment, natural resources R&D, energy conservation and fossil energy R&D, environmental health sciences, studies of environmental impacts of energy and industry, earth sciences, ocean sciences, atmopsheric sciences, environmental technology, biodiversity, and environmental impacts of agriculture.

Table 4. U.S. Federal R&D in Priority Areas, Historical

Nanotechnology

(budget authority in millions of current dollars, by federal agency)

	$ (millions)						
	FY 1999 Actual	FY 2000 Actual	FY 2001 Actual	FY 2002 Actual	FY 2003 Actual	FY 2004 Estimate	**FY 2005 Budget**
National Science Foundation	* *	97	150	204	221	254	**305**
Department of Defense	* *	70	125	224	322	315	**276**
Department of Energy	* *	58	88	89	134	203	**211**
National Aeronautics and Space Admin.	* *	5	22	35	36	37	**35**
Department of Commerce	* *	8	33	77	64	63	**53**
National Institutes of Health	* *	32	40	59	78	80	**89**
US Department of Agriculture	* *	0	2	0	0	1	**5**
Environmental Protection Agency	* *	0	5	6	5	5	**5**
Department of Homeland Security *	* *	0	0	2	1	1	**1**
Department of Justice	* *	0	1	1	1	2	**2**
TOTAL Nanotechnology	247	270	466	697	862	961	**982**

Source: U.S. National Science and Technology Council's subcommittee on
Nanoscale Science, Engineering and Technology (NSET).

Figures are rounded to the nearest million. Changes calculated from unrounded figures.

All years include regular and supplemental (emergency) appropriations.

* Department of Transportation programs transferred to the new Department of Homeland Security in FY 2003.

** - Agency details not available for FY 1999.

FY 2004 figures represent latest estimates of most recent fiscal year.

FY 2005 figures represent latest estimates of R&D in FY 2005 budget request.

U.S. fiscal year is from October to September.

Nanotechnology: Federal agency programs in the multi-agency
National Nanotechnology Initiative (NNI).

Table 5. U.S. Federal R&D in Priority Areas, FY 1998-2005
HEALTH - NIH Budgets by Institute and by Funding Mechanism
(budget authority in millions of current dollars, by NIH ICs)

	FY 1998 Actual	FY 1999 Actual	FY 2000 Actual	FY 2001 Actual	FY 2002 Actual	FY 2003 Actual	FY 2004 Estimate	**FY 2005 Budget**	Change 98-05 %
NIH Budget by Institute:									
Cancer	2,547	2,892	3,300	3,740	4,114	4,588	4,736	**4,870**	91.2%
Heart, Lung and Blood	1,531	1,775	2,025	2,293	2,554	2,792	2,878	**2,964**	93.6%
Dental & Cranofacial Research	209	238	269	307	342	371	383	**394**	88.6%
Diabetes & Digestive & Kidney Dis	901	1,021	1,141	1,404	1,560	1,721	1,821	**1,876**	108.2%
Neurological Disorders and Stroke	781	897	1,030	1,176	1,309	1,455	1,501	**1,546**	97.9%
Allergy and Infectious Diseases	1,352	1,571	1,812	2,069	2,526	3,703	4,303	**4,426**	227.3%
General Medical Sciences	1,066	1,203	1,371	1,532	1,698	1,847	1,905	**1,960**	83.8%
Child Health & Human Dev.	675	752	861	982	1,109	1,204	1,242	**1,281**	89.8%
Eye	356	396	450	509	580	632	653	**672**	88.6%
Environmental Health Sciences	330	388	503	571	644	696	709	**731**	121.4%
Aging	519	600	688	789	891	993	1,025	**1,056**	103.4%
Arthritis & Musculoskeletal & Skin	275	306	349	396	447	486	501	**515**	87.4%
Deafness & Commun. Disorders	201	231	264	302	341	370	382	**394**	95.8%
Mental Health	750	854	974	1,108	1,234	1,339	1,381	**1,421**	89.4%
Drug Abuse	527	617	687	792	892	965	991	**1,019**	93.4%
Alcohol Abuse and Alcoholism	227	259	293	342	383	416	428	**442**	94.7%
Nursing Research	64	70	90	105	120	130	135	**139**	117.5%
Research Resources	454	561	675	812	985	1,139	1,179	**1,094**	141.0%
Human Genome Research	218	284	336	382	428	464	479	**493**	126.0%
Complementary & Alternative Med.	0	51	78	89	104	113	117	**121**	- -
Fogarty International Center	28	35	43	51	56	62	65	**67**	139.9%
National Library of Medicine	161	182	215	242	274	298	308	**325**	102.0%
Office of the Director	296	256	162	192	253	286	327	**360**	21.5%
Minority Health/Health Disparities	0	0	98	132	157	186	191	**197**	- -
Biomed. Imaging/Bioengineering	0	0	0	69	262	280	289	**298**	- -
Buildings and Facilities	207	197	165	161	296	639	99	**100**	-51.9%
Total NIH Budget	13,675	15,633	17,880	20,549	23,559	27,173	28,028	**28,757**	110.3%
minus Est. Research Training	*-444*	*-509*	*-503*	*-590*	*-653*	*-712*	*-749*	***-764***	*71.9%*
minus Other Non-R&D	*-121*	*-128*	*-143*	*-152*	*-192*	*-64*	*-59*	***-71***	*-41.7%*
Total NIH R&D	13,110	14,995	17,234	19,807	22,714	26,398	27,220	**27,923**	113.0%
NIH Budget by Funding Mechanism:									
Research Project Grants	7,559	8,503	9,807	11,159	12,514	13,704	14,507	**14,894**	97.0%
SBIR / STTR Grants [3]	269	315	362	418	503	538	602	**618**	129.7%
Research Centers	1,168	1,385	1,563	1,859	2,117	2,425	2,552	**2,704**	131.5%
R&D Contracts	812	1,029	1,164	1,371	1,797	2,399	2,817	**2,706**	233.2%
Intramural Research	1,434	1,567	1,761	2,015	2,234	2,547	2,662	**2,768**	93.0%
Other Research	632	809	1,439	1,221	1,446	1,587	1,669	**1,720**	172.1%
Research Mngmt. & Support	497	541	601	720	786	921	985	**1,017**	104.6%
Research Training	428	509	540	590	653	712	749	**764**	78.5%
All Other	876	975	643	1,196	1,509	2,340	1,484	**1,568**	79.0%
Total NIH Budget	13,675	15,633	17,880	20,549	23,559	27,173	28,028	**28,757**	110.3%

Source: AAAS, based on OMB data for R&D in the FY 2005 Budget,
agency budget documents, and information from agency budget offices.
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