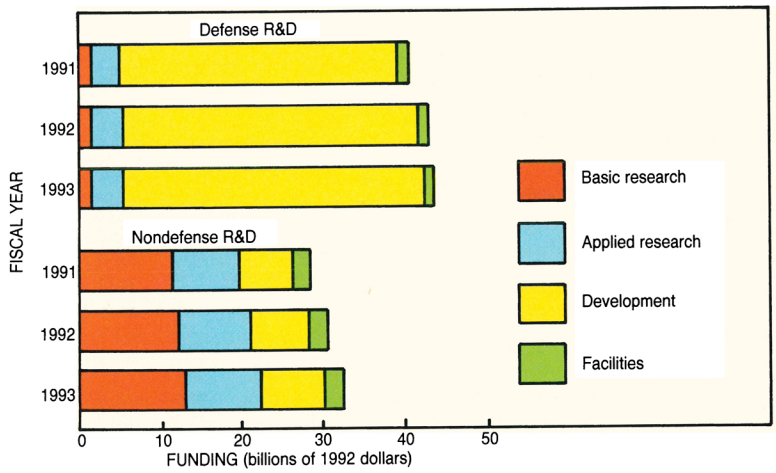
CHEERS FOR BUSH'S 1993 R&D BUDGET CUT SHORT BY PROBLEMS AND PESSIMISM

In the best of times, Washington's annual budget ritual is variously described as disturbing and disorderly—on occasion even disgusting. Last year President Bush introduced his budget in the shadow of the Persian Gulf War, and Congress completed its work on it in the aftermath of the failed coup in the Soviet Union and amid the uncertainty of a rapidly disintegrating Soviet society. This year the budget process is taking place in a more unsettling period: A series of events, from the maladroit House banking operations to the traumatic riots in Los Angeles's inner city, have vexed the nation. Just as unsettling inside Washington's Beltway is the prevailing mood about the fiscal 1993 budget exercise. The combination of the most obdurate economic recession since the 1930s, the severe limits the White House and Congress imposed on discretionary spending and the inability to stanch the flow of red ink now suggest that a budget debacle is imminent. Though President Bush's budget for fiscal 1993 asks for a record $1.52 trillion, for all practical purposes, when inflation is taken into account, the budget shows no real growth.

The budget deficit this fiscal year, which ends on 30 September, is reckoned to approach $400 billion—a figure never before encountered by the US or any other nation. If that figure doesn't boggle the mind, consider that almost 51% of the entire budget would go toward mandatory entitlement programs such as Social Security, Medicare and Medicaid. Another 19%, or about $281 billion, would be spent on defense—though many lawmakers are trying to pare down the Pentagon budget to get a "peace dividend." What's left is 16%, some $225 billion, to cover all the domestic discretionary programs—from Head Start classes for poor kids to space exploration and physics research.

The anticipated reduction in tax receipts makes the country's financial situation more depressing. Both personal and corporate incomes are certain to be lower this year as a result of the recession that began in 1990, just around the time that Congress and the White House were putting the finishing touches on the Budget Enforcement Act, an agreement to reduce the deficit by $494 billion in five years. The fact is, certain programs are laying out more than was expected at the time the budget agreement was reached. Some, such as Aid to Families with Dependent Children, food stamps and Medicaid, always cost more when the economy turns down.



Defense and civilian R&D have experienced relatively modest budget changes in recent years. The most notable increase has been in civilian basic research. (Source: Office of Management and Budget.)

If one of the nation's premier pollsters, Daniel Yankelovich, president of the Public Agenda Foundation, is right, the high level of public anger with the political process does not result from specific events in Washington or Los Angeles but from a widespread anxiety about the nation's economic and political future. According to Yankelovich, most Americans worry that something has gone terribly wrong with the way the country works.

"It is clear to many observers of the nation's scene," writes Leonard Silk, an economics columnist for *The New York Times*, "that most of what the government takes in through the existing tax system is already committed to entitlement programs, servicing the debt, military programs, and the cost of bailing out the savings and loans, with little left over for any major new initiatives."

The crisis in Washington is symbolized by at least two unexpected developments: the resignation or retirement so far of 55 representatives and 7 senators, and the bipartisan efforts to approve a constitutional amendment mandating a balanced Federal budget. These actions, most members of Congress claim, have a common origin: frustration in coming to grips with increasing government expenditures, in paring down the gargantuan public debt and in providing for the economic, technical, social and educational needs of the country. Lawmakers admit their failure to impose fiscal discipline despite their best intentions. Their attempts to do this began with the 1985 Gramm–Rudman–Hollings budget balancing act, which was soon ridiculed as an oxymoron and gave way to the 1990 agreement that placed tight caps on all appropriations for discretionary defense, do-

Department of Energy physics-related programs

	FY 91 actual	FY 92 request	FY 92 current	FY 93 request
		(millions of dollars)		
High-energy physics				
Physics research	135.1	150.4	145.4	145.9
Technology research, including detectors	67.4	73.8	73.8	69.4
Facilities operations				
Fermilab	130.3	136.9	136.4	142.7
SLAC	86.7	90.3	89.5	91.5
Brookhaven, with Alternating Gradient Synchrotron	39.2	42.2	42.6	45.0
Other operations, including computer networking systems	3.2	6.2	2.2	2.7
Capital equipment	83.0	87.7	87.7	73.2
Construction				
Accelerator improvements, mainly Tevatron and SLC	14.5	15.8	15.8	15.1
General plant (safety and environmental projects)	12.3	13.4	13.4	12.8
Fermilab linac upgrade	12.0	6.2	6.2	0
Fermilab main injector	0	43.5	15.0	30.0
Total high-energy physics	582.7	666.4	628.0	630.9
Superconducting Super Collider				
R&D and operations	114.6	103.6	103.6	116.8
Capital equipment	33.0	56.3	56.3	63.0
Construction	93.9	373.8	323.8	470.2
Total SSC	241.5	533.7	483.7	650.0
Nuclear physics				
Low-energy research				
Universities, mainly Texas A&M, Duke and U. of Washington	3.0	3.2	3.1	3.3
National laboratories	3.2	3.3	3.3	3.2
Reactors, including Tristan and NIST	1.1	0.9	0.9	0.9
Other research, including SAGE and Sudbury	4.2	3.4	5.9	5.9
Accelerator operations	3.2	3.4	3.4	3.6
Data measurements and evaluations	11.2	11.8	11.8	9.2
Medium energy, including LAMPF, Bates and CEBAF				
Research	37.1	40.0	40.0	40.8
Facilities operations	60.2	68.1	68.1	70.6
Heavy ion, mainly Berkeley Bevalac, Brookhaven Tandem AGS, Argonne Atlas and universities				
Research	34.6	37.2	37.2	39.4
Facilities operations	36.0	37.5	37.5	28.6
Nuclear theory	13.1	14.0	14.0	14.8
Capital equipment for detectors and data acquisition	24.1	28.0	30.0	32.2
Construction				
CEBAF	58.5	31.8	41.8	33.0
Brookhaven Relativistic Heavy Ion Collider	13.5	49.4	49.4	71.4
Accelerator improvements and modifications	3.8	4.1	4.1	3.2
General plant projects	3.9	3.9	3.9	3.5
Total nuclear physics	310.7	342.4	354.4	363.5

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mestic and foreign assistance programs.

It is customary each spring to allocate discretionary spending among all 13 appropriations subcommittees in the House and Senate. This enables lawmakers to begin marking up their spending bills and debating these on the floor. But this has yet to happen this year because members of Congress are loath to wield the budget axe in an election year.

One of the House budget committee's senior staffers, Michael L. Telson, who holds a PhD in electrical engineering from MIT, foresees "a lot of pain" for the science community in fiscal 1993. The problem is that the President's budget for discretionary domestic programs, even if held to the 3.5% rate of inflation, would still exceed the spending caps by $6.4 billion. Along with programs in almost every agency, science and engineering in the National Science Foundation, the Environmental Protection Agency and NASA would be targets for reductions, Telson explained to the annual R&D colloquium of the American Association for the Advancement of Science on 16 April. Congress always finds it difficult to trim veterans' benefits, public housing and community development block grants—which all vie for funds in the same budget function as NSF, EPA and NASA. To make matters worse for science, since Telson's talk the President and Congress have agreed to come to the rescue of urban centers such as Los Angeles this year and pressure will be on Washington to promise even more for the inner cities and their inhabitants next year.

Scrambling for funds

It so happens that under Bush's 1993 budget, almost half of all domestic discretionary growth would be allocated to the agencies within the scope of a single House appropriations subcommittee—the one that oversees veterans benefits, urban housing and development and NSF, EPA and NASA. As generous as that may seem, the total increase for all domestic discretionary spending amounts to $8.5 billion—up 4.5% from this year's allocation. But there are nine other appropriations subcommittees seeking to share in any new funds, and each is negotiating for a modest rise of 2% or 3%. When Walter Massey, NSF's director, appeared in late February before the subcommittee dealing with his agency, the chairman, Representative Bob Traxler, a Michigan Democrat who has announced that he is not running for reelection this year, confided that any increase greater than 4.5% would be "hopeless." When Massey said he was still hoping for the full 18% boost the President had requested for fiscal 1993, Traxler sighed and said, "I have to tell you there will be hard times ahead for research programs."

The only way of averting this grievous situation is to remove the caps from the budget agreement or to tear down the so-called fire walls that separate defense and domestic programs, thereby allowing Congress to shift money from the Pentagon to nondefense accounts. Some Democrats tried to breach the walls in March, arguing that they no longer make sense in the post-cold-war era. Representative John Conyers of Michigan and Senator James Sasser of Tennessee proposed bills to do this without raising the Administration's total budget request. But the move was stopped in the Senate on 26 March and then foiled in the House a few days later.

The failure of this is bound to affect R&D adversely under the current pressures to rescue the nation's troubled cities. To live under the caps, Telson figures, all domestic programs would need to be cut by 1.3% from their current funding levels. The alternative to exacting such a sacrifice is to select certain programs and projects for the chopping block so that others might survive and some of

those even prosper.

Playing a zero-sum game

That's precisely what President Bush proposed on 29 January. His budget provides, for example, for growth in R&D at the expense of low income housing, grants for urban mass transit and Amtrak. The Administration would give almost half of the entire budget increase in 1993 to such R&D programs as the Strategic Defense Initiative (which would receive a 31% jump, to $5.4 billion), the space station (an 11% increase, to $2.25 billion), the Superconducting Super Collider (up 34%, to $650 million) and the President's short list of special research initiatives, such as global change, computers and communication, and science and mathematics education. As Telson explains the situation, "In a zero-sum budget, the only game plan is to rob Peter to pay Paul." But, he adds, "Congress is almost certain not to go along with this."

D. Allan Bromley, the President's science adviser, similarly stated at his budget briefing that R&D programs are trapped in a "truly zero-sum game" in which increases need to be offset by cuts elsewhere within specific budget categories. In a Presidential election year it is politically difficult to cut domestic programs, many of them with vocal constituencies, to raise the stakes for science. The Administration's rationale for skewing domestic priorities toward R&D, said Bromley, is enlightened self-interest—the expectation that such investments will pay off in commercial applications, economic growth, international competitiveness and improved health care.

The proposed budget, which Congress is certain as always to alter to suit itself before it is enacted into law, is selective in its support of R&D. The total budget for Federal science and technology programs would grow from $74.6 billion this year to $76.6 billion—an increase of less than 3%. Funds for defense R&D would go up only 1.2% to $43.3 billion. If the Defense Department gets this full sum, Pentagon programs will corner 57% of the government's entire expenditure for R&D—down from the current 60% share and a further fall from the Reagan era high of nearly 70%. By contrast, the Bush budget makers would award civilian R&D a 7% increase, from $28.3 billion to $30.4 billion. In the combined civilian and defense R&D total, basic research would fare somewhat better, rising from $13.3 billion this year to $14.3 billion in 1993, an increase of

Department of Energy physics-related programs, continued

	FY 91 actual	FY 92 request	FY 92 current	FY 93 request
	(millions of dollars)			
Basic energy sciences				
Materials sciences, including solid-state physics				
Research, including R&D for Advanced Neutron Source	144.6	156.7	159.0	169.0
Facilities operations, including commissioning and operation of Lawrence Berkeley 1–2-GeV light source and R&D for Argonne 6–7-GeV light source	80.5	100.4	98.1	121.2
Congressionally directed projects, including Ames Laboratory	46.8	0	0	0
Chemical sciences				
Research	95.3	98.0	101.4	115.1
Facilities operations, mainly Oak Ridge	60.3	60.3	58.6	60.3
Applied mathematical sciences, including DOE's contribution to the President's High Performance Computing Initiative	52.1	75.5	81.5	91.0
Engineering and geosciences	33.9	35.8	35.8	39.5
Advanced energy projects				
Research on novel, high-risk projects	14.3	10.8	10.8	11.9
Congressionally directed projects	10.4	0	44.0	0
Energy biosciences, performed mainly at universities	21.8	24.7	24.7	27.6
Program direction	6.5	7.5	7.5	8.4
Capital equipment and instrumentation	36.8	37.0	37.0	46.3
Construction and modifications				
Accelerator and reactor improvements	6.8	11.1	4.6	6.2
Lawrence Berkeley 1–2-GeV light source	22.9	6.5	8.0	1.6
Argonne 6–7-GeV light source	71.3	90.4	93.9	114.6
Total basic energy sciences	705.8	714.7	764.7	813.9
Major user facilities, including light sources	140.9	160.7	155.0	181.5
University and science education				
Laboratory cooperative science centers at DOE labs	23.9	27.6	26.1	36.6
University programs, including museums and EPSCOR	13.0	7.8	18.7	9.8
University reactor fuel assistance	3.2	3.7	4.7	3.7
University research instrumentation	4.8	5.0	5.0	5.6
Laboratory technology transfer	2.6	4.9	9.9	15.1
Fusion energy				
Magnetic confinement systems including upgrades*	150.9	183.3	183.3	182.8
Applied plasma physics, including theory and computing	62.9	61.8	61.8	62.5
Development and technology, including ITER work	46.6	56.7	56.7	67.6
Planning and projects	1.0	4.2	4.2	4.8
Inertial fusion energy**	1.6	8.2	8.2	8.2
Program direction	5.6	7.5	7.5	8.8
Capital equipment and instrumentation	10.4	11.0	11.0	21.0
Construction, including safety improvements	7.6	4.6	4.6	4.2
Total fusion energy	286.6	337.1	337.1	359.7
Inertial fusion (weapons R&D program)				
Gas laser, including Aurora and Nike	10.9	28.9	11.8	11.9
Glass laser, including Nova and Omega	102.3	103.0	106.4	117.7
Pulsed power, including PBFA II and Hermes III	29.3	31.5	31.5	30.0
Supporting activities	15.4	1.9	15.6	15.6
Capital equipment, including Omega upgrade	17.1	17.2	29.5	20.7
Construction, including safety and security improvements	2.2	6.2	6.8	1.0
Total inertial fusion	177.2	188.7	201.6	196.9
Weapons activities				
Research, development and testing, including SDI R&D	1741.7	1764.0	1943.9	1888.1
Production and surveillance	2945.5	2548.5	2515.5	2566.3
Program direction	106.4	164.0	164.0	355.8
Total weapons activities	4793.6	4476.4	4623.4	4810.2
New production reactors	375.0	500.0	515.5	153.8
Nuclear materials production and enrichment	2277.2	1876.9	1876.9	1776.7
Verification and control technologies	196.4	235.0	230.0	241.7
Nuclear safeguards and security	91.0	97.1	96.0	104.2
Nuclear warhead complex cleanup and restoration	3596.9	5000.0	4283.2	5316.7

*Heavy Ion Fusion Accelerator Research (HIFAR) will be transferred into fusion energy program in 1992.
**A new component of the nondefense fusion program, this nonetheless continues to be coordinated with inertial fusion in DOE's defense programs.

National Science Foundation physics-related programs

	FY 91 actual	FY 92 request	FY 92 current	FY 93 request
	(millions of dollars)			
Mathematical and physical sciences				
Physics research				
Elementary particles	41.9	47.2	44.9	48.4
Nuclear sciences	42.7	47.2	44.8	48.4
Atomic, molecular and optical	16.0	18.0	17.9	19.0
Theoretical	18.7	19.9	20.0	20.8
Gravitational	10.7	11.2	10.8	11.9
Total physics	130.0	143.5	138.4	148.6
Materials research				
Condensed matter physics	21.5	24.5	23.9	29.1
Solid-state chemistry and polymers	18.0	20.2	19.7	24.7
Metals, ceramics and electronic materials	18.6	22.6	21.6	27.7
Materials theory	11.0	13.0	12.2	14.8
National facilities and instrumentation	17.8	18.5	18.2	19.7
Materials Research Laboratories and Research Groups	47.2	50.2	48.0	51.4
Total materials research	134.1	149.0	143.6	167.5
Chemistry, including physical chemistry	104.7	115.3	112.3	125.9
Mathematical sciences	73.2	81.2	78.6	85.0
Astronomical sciences				
Solar system, stellar evolution and galactic studies	33.9	37.7	38.0	41.6
National Astronomy and Ionosphere Center*	8.6	10.4	10.5	11.1
National Optical Astronomy Observatories, including Kitt Peak and Cerro Tololo	25.7	28.0	28.5	29.5
National Radio Astronomy Observatory, including VLBA construction	31.4	33.4	35.3	37.8
Total astronomical sciences	99.6	109.5	112.3	120.0
Major research facilities				
National High Magnetic Field Laboratory**	12.0	12.0	10.0	14.0
Laser Interferometer Gravitational Wave Observatory***	0.5	23.5	15.9	48.0
8-meter optical–infrared telescopes†	4.0	16.0	12.0	17.0
Green Bank (Virginia) radiotelescope††	0	0	0	0
Geosciences				
Atmospheric sciences research, including global climate studies	61.3	71.7	69.2	79.3
National Center for Atmospheric Research	48.9	56.2	51.4	64.7
Upper atmospheric facilities, including remote sensing by university scientists, other agencies and private groups	6.4	7.0	6.6	7.9
Earth sciences, including geophysics, lithospheric studies, earthquake prediction and instrumentation	70.8	77.6	76.2	88.1
Ocean sciences, including global climate processes	82.0	97.7	90.8	109.2
Oceanographic centers and facilities	47.7	54.5	51.6	59.3
Ocean drilling program	35.0	36.4	36.4	37.8
Arctic research program	14.9	17.7	21.3	26.0
Total geosciences	367.7	419.5	404.4	472.4
Antarctic research program†††	175.1	193.0	193.0	177.0
Computer and information science and engineering				
Computer and computation theory and research	31.3	37.9	34.8	43.0
Information, robotics and intelligent systems	23.6	29.2	27.0	36.8
Microelectronic information processing systems	18.5	23.5	21.5	30.4
Advanced scientific computing, mainly at NSF's four supercomputing research centers	66.5	72.1	69.6	86.7
Networking (NSFNet) and communications research	29.8	42.2	35.5	48.1
Cross-disciplinary activities	19.8	24.5	22.5	27.1
Total computer and information science and engineering	189.5	229.5	210.9	272.2
Academic research facilities and instrumentation				
Research facilities modernization	39.0	0	16.5	0
Academic research instrumentation	0	50.0	16.5	33.0

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7.5%—a gain resulting mainly from the Administration's emphasis on the President's favorite science and technology programs.

This does not mean the Bush budget is without critics. The ink was barely dry on the 1713-page budget document when Representative George E. Brown Jr, a California Democrat who heads the House Committee on Science, Space and Technology, took a potshot at the proposed allocation for defense R&D. Brown argued for allotting a larger proportion of R&D funds to civilian agencies, now that justification for some Pentagon programs has collapsed along with the Soviet Union. "Although the trend is certainly in the right direction, the pace is clearly insufficient in light of both the declining military threat and the importance of civilian R&D to economic recovery," Brown asserted.

Indeed, the big winner in the President's proposed budget is SDI. Congress is certain to take aim at the high price of SDI, more popularly known as "Star Wars"—though for the President and many Republican lawmakers it is a litmus test for loyalty to the Reagan legacy. The program was scaled back last year from its conceptual design as an elaborate constellation of orbiting battle stations intended to shield the US against a massive assault of missiles. Gone are the plans to deploy exotic particle-beam accelerators and x-ray laser devices to detonate enemy warheads. Instead of the reduction in SDI's aims, what is remembered on Capitol Hill is that over the past nine years the program has already spent $27 billion without producing an antimissile weapon. Still, a lesser dream of developing a flotilla of up to 1000 space-based rockets, nicknamed "Brilliant Pebbles" for their technical sophistication and relatively small size, continues to excite the Bush Administration and some Republican legislators.

While arguments for such space-based weaponry are wearing thin in Congress, leading lawmakers in both parties have endorsed an SDI plan to develop a smaller ground-based system for defense against a limited or accidental attack. This scheme would deploy up to 750 rockets at four sites in the continental US as well as one each in Hawaii and Alaska, which are too distant to be protected by the other bases. Program officials say the total cost of the system will be $25 billion—almost the same as the estimate given by the Pentagon shortly after President Reagan revealed his vision of Star Wars in a TV address in 1983. The first site will be near Grand Forks, North Dakota, or somewhere in the Northeast, perhaps at Loring Air Force Base in Maine.

Prime targets on the Hill

Two civilian big science projects are already prime targets on Capitol Hill. Last year, cheered on by 15 professional groups, organized by The American Physical Society, that had signed a joint statement sharply critical of the space station's scientific ambitions, the House Appropriations Committee recommended terminating the project. Then, in an impressive display of political prowess, NASA and its allies in the aerospace industry easily wiped out the opposition and Congress voted the full budget request of $2.03 billion for 1992. Once more this year the station is under attack by scientists and some

lawmakers. An amendment to remove the station from NASA's budget authorization bill was taken to the House floor on 29 April by Tim Roemer, a Democrat of Indiana. The amendment failed, with 159 members voting for it and 254 against. Congressional staffers say the station is not in any real danger of being junked, though it may not get as much as the Bush Administration has requested.

The other big project under the gun is the SSC. Its officials plan to plug in four full-sized prototype dipole magnets and one quadrupole in August as the first real test of the system. The magnets will operate together in a small portion of the proposed 54-mile oval tunnel. Every summer for the past four years the SCC has been attacked in Congress for limiting high-energy physics programs at other Energy Department laboratories and for failing to attract foreign funds to pay one-third of the machine's estimated total cost of $8.24 billion. And each fall, influential senators from Texas and other states where project contractors are located lead the vote for funding, though the project was funded at $50 million less than the President's request in 1992 and, say Congressional sources, it is likely to be cut by at least $100 million this time around. If the Office of Management and Budget had its way, the SSC would have gotten $550 million in the 1993 request, a 14% increase from its $484 million allocation this year. But its enthusiasts in Congress sent their message to the White House and succeeded in boosting the request to $650 million.

The cries of despair over research funds by academic scientists and professional societies have evidently paid off. Bromley fought some rearguard actions with OMB over small science. As a result, the 1993 budget includes $8 billion of additional money, an increase of 9% for individual investigators. "Individual investigators are the backbone of the US scientific and engineering enterprise," says the hefty budget book, "and have been the source of many of America's most pioneering inventions and discoveries." Bromley boasted that the largest increases in the 1993 budget "testify to [the Administration's] abiding commitment to make the investments in science and technology that this nation needs to remain prosperous and secure." And NSF Director Massey led the cheers of "small science" advocates in welcoming the 18% increase in his budget as "a validation that science research is truly a public good."

National Science Foundation physics-related programs, continued

	FY 91 actual	FY 92 request	FY 92 current	FY 93 request
	(millions of dollars)			
Education and human resources				
Systemic reform, including Statewide Systemic Initiatives, instructional materials and EPSCOR	16.4	33.5	44.5	76.0
Elementary and secondary education	149.0	166.4	192.4	186.3
Undergraduate education	52.4	61.0	61.0	63.0
Graduate education and research development	44.0	55.4	78.4	57.9
Human resource development	34.6	44.6	46.6	50.1
Research, evaluation and dissemination	25.6	29.2	42.2	46.2
Total education and human resources	322.0	390.0	442.0	502.5

*NASA contributes to the support of the 305-meter radio–radar telescope at Arecibo, Puerto Rico.
**More than half of the estimated $140 million total cost of the new magnet lab will be provided by the State of Florida. Funds for MIT's Francis Bitter National Magnet Laboratory are included in Materials Research Laboratory line item.
***Additional funds for LIGO R&D, totaling $4 million in FY 92 and $5 million in FY 93, will be provided from the gravitational program in the physics division.
†The two proposed Gemini telescopes, which would cost a total of $176 million, require collaboration with the United Kingdom, Canada and another nation still to become a partner.
††Construction costs of the 100-meter-class Green Bank Telescope come from $69.5 million allocated by Congress in FY 89 and FY 90 for replacing the radiotelescope that collapsed in November 1988.
†††Includes Defense Department funds of $105 million in FY 92 and $14 million in FY 93 to be transferred to NSF for logistics and environmental cleanup.

Yet, unlike the R&D budgets submitted in the past decade, this one boasts of no new starts for science facilities. Instead, it concentrates on five so-called Presidential initiatives. Combined with the SSC and space station projects, the initiatives, which cross the traditional bureaucratic boundaries of the various agencies, garner the entire increase proposed for civilian R&D. They account for $8.2 billion in 1993, an increase of $2.4 billion above current spending and equal to the entire increase proposed for R&D.

The initiatives were put together by panels operating under the Federal Coordinating Council on Science, Engineering and Technology, a once-moribund group that Bromley resurrected to provide better planning and focus for programs that traditionally were handled piecemeal by individual agencies. Last year FCCSET produced three so-called Grand Challenges in the budget: a 9-agency high-performance computing initiative aimed at increasing the speed and capacity of computer hardware by a factor of 1000 and the transmission rate of data by a factor of 100; an 11-agency global change research effort; and an 11-agency program to advance precollege science and math education. In each case, Congress added to the budget request, and so this year the Administration is coming back for more: $803 million, an increase of $148 million (23%) for computing and communications; $1.37 billion, an increase of $262 million (24%) for research to better understand the Earth's climate system, ozone depletion and global warming; and $2.1 billion, up $137 million (7%), for elementary and secondary schooling and teacher training in science and math.

Impressed with the reaction

The Administration was sufficiently impressed with the reception last year that it added two new initiatives—one on advanced materials and processing, which would receive $1.8 billion (an increase of 10% over currently ongoing programs within 5 agencies), and the other in biotechnology research, with a request for $271 million (7%) distributed among 12 Federal agencies. On 5 March, more than a month after the budget was released, Bromley announced that FCCSET had approved another initiative, this one in manufacturing technology. It is intended to build on existing advanced manufacturing R&D programs—mainly at DOD, NASA, the Energy Department and the National Institute of Standards and Technology (the new name for the old National Bureau of Standards)—in such precompetitive technologies as sensors, robotics, computer integration and computer networks. The 1993 budget proposes a total of about $1 billion for this type of R&D, including $321 million (an increase of 27%) for civilian-related programs.

Not every official in the government's science agencies was pleased with the Bush budget. NASA Administrator Richard Truly, who was deposed from his job soon after the budget was presented (PHYSICS TODAY, April, page 77), came under pressure from Congress and the aerospace industry to keep the space station

NASA physics-related programs

	FY 91 actual	FY 92 request	FY 92 current	FY 93 request
	(millions of dollars)			
Physics and astronomy				
Gamma Ray Observatory development	22.0	0	0	0
Global geospace science: Solar–terrestrial program	96.6	65.3	75.3	60.1
Advanced X-Ray Astrophysics Facility development	101.2	211.0	151.0	174.0
Payload and instrument development	92.6	115.9	116.5	78.2
Shuttle–Spacelab payload support, including Atlas	88.8	88.0	88.0	101.1
Space station integration planning and payloads	3.0	0	0	0
Explorer program, including COBE and EUVE	99.8	107.9	105.0	112.5
Mission operations and data analysis				
Hubble Space Telescope operations and servicing	186.0	209.2	209.2	214.2
Hubble Space Telescope data	35.9	36.0	36.0	42.3
Astrophysics mission operations and data	68.5	98.3	92.7	115.4
Space physics mission operations and data	21.5	44.9	42.9	69.0
Supporting research, analysis and technology	98.3	103.1	70.5	81.4
Suborbital programs				
Sounding rockets	31.3	34.3	34.3	37.3
Airborne science and applications	11.5	12.0	12.0	12.6
Balloon experiments	12.2	14.7	13.9	15.4
Total physics and astronomy	969.2	1140.6	1047.3	1113.5
Planetary exploration				
Ulysses	2.8	0	0	0
Mars Observer development	88.5	54.4	76.9	0
Mars balloon relay for planned 1994 Russian mission	1.5	1.2	1.2	0
Cassini development	143.0	328.0	210.7	210.0
Mission operations and data analysis	170.2	150.5	156.1	170.3
Supporting research, analysis and technology	67.8	93.2	90.7	106.9
Total planetary exploration	473.7	627.3	535.6	487.2
Earth science and applications				
Earth Observing System for "Mission to Planet Earth"	150.6	253.4	184.4	308.4
Earth Observing System data information operations	36.0	82.6	82.6	82.6
Earth probes, including Scatterometer and Ozone Mapper	51.7	68.2	92.8	88.9
Remotely piloted aircraft for Earth sensing	0	5.0	0	0
Upper Atmosphere Research Satellite mission	62.0	18.2	0	0
Ocean Topography Experiment	80.4	51.9	59.9	0
Payload and instrument development	49.1	48.6	39.6	49.4
Mission operations and data analysis, including Landsat	39.4	56.3	83.8	142.1
Interdisciplinary research	12.4	2.5	2.5	2.6
Climate and geophysics modeling and data analysis	44.3	45.0	49.0	45.0
Radiation and ecosystem dynamics, atmospheric chemistry and solid Earth science	107.5	114.3	114.3	117.6
Laser research facilities for crystal deformation studies	8.7	9.0	9.3	9.0
Airborne science for Earth sensing and atmospheric research	20.2	20.6	20.3	22.9
Total Earth science and applications	662.3	775.6	738.5	868.5
Materials processing in space				
Research and analysis	13.7	16.6	16.6	17.5
Materials experiment operations	84.9	85.5	80.5	129.1
Space station utilization, mainly for protein crystal growth	0	21.3	19.3	48.7
Commercial microgravity R&D enhancements	3.7	2.4	2.4	0
Total materials processing in space	102.3	125.8	118.8	195.3
Commercial programs				
Technology utilization, including materials and electronics	24.4	32.0	32.5	31.7
Commercial use of space, especially for automation and robotics, materials processing and purification, and crystal growth	63.6	118.0	116.1	139.9
Total commercial programs	88.0	150.0	148.6	171.6
Academic programs				
Graduate student researchers	6.9	7.0	7.0	8.2
Summer faculty fellowships at NASA centers	3.8	4.0	4.0	4.0
Innovative research at universities and colleges	2.7	2.9	2.9	3.1
Space application studies at universities	2.8	2.8	2.8	2.8
Aerospace education services	6.0	6.1	6.1	7.0
Innovative pre-college education programs	3.6	4.8	5.5	7.6
Education technology, including videodiscs and software	0	0	1.5	1.0
Minority university research and education program	17.2	22.0	22.0	22.7
Space grant college and graduate fellowships	12.1	15.0	15.0	15.0
Total academic programs	55.1	64.6	66.8	71.4
Space exploration studies and precursor missions	(3.5)*	(15.0)*	(5.0)*	31.8
Space Station Freedom program	1900.0	2028.9	2028.9	2250.0

*Budgeted in FY 91 and FY 92 under space research and technology.

flying high, no matter how intense the opposition from scientists. When OMB demanded that he make some budget cuts so that the station could be funded in these tight times, he chopped a few previously approved projects from space science—notably CRAF, a US–European project to rendezvous with a comet and to fly through the asteroid belt, and STORE, a test for gravitational waves using the Gravity Probe-B instrument on a shuttle flight. The National Institutes of Health would receive a total increase of only 5%, enough to stay just ahead of inflation. But, if budget history is right, Congress will increase the funding for NIH.

Nevertheless, the overall increases for civilian R&D are noteworthy for the fact that they exist at all in a budget awash in red ink. At a time when all politicians face a crisis of public confidence, it's not surprising that the fiscal 1993 budget is not uppermost in their minds. Jobs, jobs, jobs are the prime concern. Many in Congress believe that defense industry cuts are largely to blame for the severity of the recession. Over the past year manufacturing has lost 300 000 workers. Six defense industries—ordnance, communications equipment, navigation gear, aircraft, ships and guided missiles—account for about 40% of that decline. Many lawmakers have backed away from their previous plans to seek sharp reductions in the military budget in fiscal 1993. In January, Defense Secretary Dick Cheney sent forward a $281 billion military budget request for fiscal 1993—some $10 billion below the current appropriation. But as some lawmakers clamored for deeper reductions in the Pentagon's budget request and an end to the restrictions enacted in 1990 that prevent the transfer of miliary savings to domestic discretionary spending this year, the likelihood of a brawl between the Administration and Congress grew. In the intervening months the Senate embraced the Administration's plan for defense, while the House sought to trim more than $6 billion from the defense budget. In the House scenario, SDI would get $4.3 billion—$1.1 billion below the amount the Administration wants, but $700 million more than the House voted last year.

One of the most persistent myths about the 1980s is that R&D received large increases from Washington. Throughout the Reagan years, with the end of "stagflation" and the cuts in tax rates, it was common for big science to grow, with billions going to SDI, the SSC, the space station and the human genome project. But these

gains were not without pain. The reality of the situation was that individual investigators were shortchanged and that the country's overall debt mounted to new heights. When Reagan entered the White House, the US was the world's largest creditor. Now it is the world's largest debtor. Under Reagan the national debt doubled to $2.3 trillion. It is now approaching $4 trillion.

Among the unsettling disappointments for many physicists who experienced what they remember as the heady R&D budgets of the 1960s, after the Soviet Sputniks motivated the US to spur its support of science, was the funding shortage of the late 1980s. Though the budgets for physics and other sciences continued to increase, total funding as a percentage of gross national product has not kept pace with R&D accounts in Japan and Germany. What's more, the number of scientists seeking support from Federal agencies has increased throughout the 1980s, with the obvious result that proposals are outpacing the available grants. Then, too, with the end of the military threat, physics is no longer seen as a field necessary for spreading Washington's largess.

Here are some highlights of the fiscal 1993 budget by agency:

Department of Energy. After the fears and frustrations generated by the charge to the Townes panel to slash projects in nuclear and particle physics by 10% (PHYSICS TODAY, December 1991, page 53), any budget increase at the Energy Department would be welcome. In fact, the Administration handed the general science program an increase of 12% or $179 million, to a total of $1.6 billion. This appears to be healthy growth, but closer examination reveals that more than half the increase would go to the SSC, leaving a paltry 3% rise for nuclear physics, all of this going to continuing construction of the Relativistic Heavy Ion Collider at Brookhaven and the Continuous Electron Beam Accelerator Facility at Newport News, Virginia. The upgrade of Fermilab's main injector, after last year's controversy with OMB over funding (PHYSICS TODAY, April 1991, page 86), would get $30 million in 1993.

The House science committee's analysis of the budget argues that the "underlying assumption" behind financing the SSC calls for the state of Texas to provide $133 million next year and for other sources to put up $100 million. The committee's report notes that the Bush budget does not specify the donors of the additional $100 million, though DOE officials continue to press Japan and South Korea for contributions. Only India, of all potential foreign donors, has made a firm commitment—of $50 million, which will be spent mainly to send that country's physicists and engineers to the SSC Lab.

Elsewhere the DOE research budget looks frozen at the 1992 level. The exceptions are those programs in basic energy sciences that have injections of funds from the FCCSET initiatives in computer technology, advanced materials, biotechnology and global change—which, all together, are getting a 7% increase above the current level. The request for fusion energy is $360 million, an increase of 6% above this year—though most of the new funds would go toward participating in the International Thermonuclear Experimental Reactor. ITER is an experimental tokamak that is now in a $1 billion design phase involving scientists and engineers from the US, the former Soviet Union, the European Community and Japan. When ITER was first conceived in 1982, it was said to be a $2 billion project. The current estimate for building it is $6.4 billion. DOE is revising its plans for the US fusion program after canceling the Burning Plasma Experiment, which was to be built at the Princeton Plasma Physics Laboratory to provide experience and information before ITER would be fully designed.

Though the department expects to get some of the peace dividend from phasing out nuclear weapons production, it is spending more money each year to clean up radioactive waste from the weapons complex and to restore the environment as best as it can. This effort is budgeted for a 25% increase next year, to a total of $5.3 billion. Of this sum, $4.6 billion would go to sanitizing the weapons complex and $706 million for scrubbing up civilian research labs. Some DOE officials are also campaigning to clean up the mess made by nuclear weapons plants in Russia, Ukraine and other FSU republics.

National Science Foundation. Amid all the red ink and slow growth that characterizes most of the 1993 budget, NSF stands out. Its increase of almost 18% is the largest of any agency's, and by surpassing the $3 billion mark it joins the major league of Federal spenders. But, as the House science committee's analysis shows, $60 million of the $454 million increase comes from an accounting anomaly that shifts logistics support

Department of Defense basic research funding (6.1 budget category)

	FY 91 actual	FY 92 request	FY 92 current	FY 93 request
	(millions of dollars)			
Army				
Research sciences, including physics and materials	171.8	179.4	178.9	166.6
Electromechanics and hypervelocity physics	0	3.0	3.0	3.9
Army laboratories, discretionary research	8.8	14.8	8.9	6.7
Navy				
Research sciences, including physics and materials	366.1	395.8	381.2	457.4
Navy laboratories, discretionary research	24.1	25.9	14.0	16.2
Air Force				
Research sciences, including physics and materials	197.4	203.2	206.4	237.4
Geophysics	35.3	40.4	36.9	42.5
Air Force laboratories, discretionary research	7.2	10.0	7.9	9.8
Defense Advanced Research Projects Agency				
Research sciences, including physics and materials	82.2	88.3	112.4	126.1
Materials and electronics technology	158.5	62.0	112.6	71.8
Manufacturing technology, including Sematech	98.0	206.2	208.3	255.4
Office of Secretary of Defense				
Research sciences, including physics and materials	82.2	88.3	112.4	126.1
Laboratory research, mainly Bethesda Naval Hospital	2.5	2.2	3.2	0
Universities research initiatives	242.2*	87.4	98.5**	99.9
Research projects	39.6***	0	0	0
US–Japan management training†	10.0	0	9.8	0
Critical Technology Institute	4.9††	0	0	0

*Includes $62 million in Congressional set-aside programs, also known as "pork barrel" allocations, as well as Congressional mandates such as $20 million for fellowships, $50 million for science and engineering traineeships at universities and $7 million for Experimental Program to Stimulate Competitive Research, or EPSCOR.

**Does not include Congressional set-asides that DOD is seeking to rescind.

***Congressional set-asides.

†A program instigated by Senator Jeff Bingaman, a Democrat of New Mexico, to educate American graduate students in Japanese business practices at four US universities: MIT, University of Michigan, University of Wisconsin and Vanderbilt.

††Mandated by Congress, at Bingaman's initiative, for a center to be established by the Office of Science and Technology Policy; it was not created in FY 91 and the funds were given to the National Science Foundation for the same purpose in FY 92.

for Antarctic research from the Navy's budget to NSF's. The action contradicts the 1990 agreement preventing any funds moving between defense and civilian budgets. Thus, as the committee's "white paper" points out, NSF's effective budget boost is 13.2%, which, if approved by Congress, would keep the agency on track to double what it got in 1987 by fiscal year 1994.

Funds for individual scientists would go up 17% in the Administration's plan, though much of this increase is destined for researchers in the FCCSET programs—advanced materials and processing (up $318 million, or 20% more), biotechnology ($205 million, or 18%), computing and communications ($252 million, or 20%) and global change research ($152 million, or 50%). While the proposed increase for education and human resources would raise the budget by only 3.1%, to a total of $479.5 million, this program has more than tripled between fiscal 1989 and fiscal 1992. In 1993, NSF proposes to consolidate its rapid growth and focus its programs more carefully. Support for major reforms of precollege education, including the new Statewide Systemic Initiative, which now involves ten states contributing matching funds, would increase by $12 million next year, up 27%.

To support research infrastructure at universities, NSF proposes an increase of $50 million for national facilities for astronomy, physics and materials science. But missing are any funds for the Academic Research Modernization Program, which appeared in the agency's budget for the past three years. The Administration has left out the program on the grounds that Congress now earmarks nearly $1 billion for pork-barrel buildings and programs, many of these at university campuses (see story below).

NASA. The theme of next year's space budget seems to be "steady as she goes." The Administration's request for $14.99 billion represents a nominal rise of only 4.5%, which is much less proposed growth than in any of the past five years. What's more, as the House science committee observes, NASA's budget is not projected to increase much in the next five years. Space station Freedom is the big gainer, and the Earth Observing System and its data acquisition and analysis program would go up by about 33%, with an increase of $120 million over the current year. To pay for these cuts, sacrifices would be required. The agency would abandon all hope of building new rocket motors for the space shuttle—a construction project located in the home district of Representative Jamie Whitten, the influential and aging Mississippi Democrat who is chairman of the House Appropriations Committee. Before he left NASA, Admiral Truly said improved rocket engines weren't needed because those developed since the Challenger explosion have worked unfailingly. Whitten is almost certain to see the situation differently.

Department of Defense. Of the funds requested for R&D, $4.3 billion would be allocated for the technology base, while $36.3 billion out of the total request of $291 billion would be spent in support of specific procurement programs. These funding levels represent increases above fiscal 1992 of only 2% for the technology base and 1% for development. The tech base contains $1.2 billion for basic research, an increase of 3%, and $3.06 billion for applied research, a rise of 2% over the current year's account. SDI is given another large bonus, with a request for $5.4 billion. To keep the overall defense budget from increasing, the Administration has announced cancellations in several once-massively-funded programs, including the Seawolf submarines and small ICBMs, as well as cutbacks in the Army's next generation tank and Comanche light helicopter.

Science often is a pawn in the zero-sum game the Federal government finds itself in. This year, in addition to the plethora of problems and the caps fixed on the discretionary parts of the budget, the large number of resignations and retirements in the House is bound to affect legislation. Insiders at Congress and OMB admit that the rites of passage for the 13 appropriations bills this fall are troublesome. Only one bill—namely the Energy and Water Development Act—is likely to be passed before fiscal 1993 begins on 1 October. None of the rest are likely to be completed before the election, and it is not at all certain that agreement on the other 12 will be reached before the 103rd Congress assembles next January. In such chaotic circumstances, the government will continue operating through a series of "continuing resolutions" passed by Congress.

—IRWIN GOODWIN

TWO WHITE HOUSE PANELS TO EXAMINE EMBATTLED RESEARCH UNIVERSITIES

The President's Council of Advisers on Science and Technology and the Federal Coordinating Council for Science, Engineering and Technology have begun independent examinations of the nation's research universities, whose financial accounts and scientific reputations are under siege. In announcing the two studies at a meeting of PCAST on 2 April, D. Allan Bromley, President Bush's chief adviser for science and technology, observed that the health of some of the most prestigious universities "has changed dramatically" since the last diagnosis in 1986 (PHYSICS TODAY, March 1986, page 65). That analysis was done under the direction of David Packard, chairman of Hewlett-Packard Co, and Bromley, then a Yale physics professor, who served as vice chairman of the study group. The group's report was issued as a "white paper" by the White House Science Council, the predecessor to PCAST.

The Packard–Bromley report, bearing the optimistic title of "A Renewed Partnership," urged the Federal government to make "substantially greater investments in our centers of learning in the 1980s and 1990s than in the 1960s and 1970s." In the earlier decades, various occupants of the White House, intent on squaring the account for campus dissent to the Vietnam War, cut back or cut out research programs and laboratory projects. Estimating that America's colleges and universities needed about $10 billion over a ten-year period for science buildings and research laboratories, the report called on the Federal government to put up half the total sum and for states, localities, universities and private sources to contribute the rest.

The report argued as a major premise that the ups and downs in Federal funding have not enabled the nation's colleges and universities to meet the increasing demands for new talent and new knowledge. It also complained that academic operations were hopelessly snarled in bureaucratic red tape, preventing both the academic institutions and their research investigators from making the