"Policy, Politics, and Science in the White House: Conversations with Presidential Science Advisors"
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Before I make some brief prepared remarks, I would like to acknowledge the contribution of one of my predecessors, D. Allan Bromley, advisor to George H.W. Bush, and a friend. Allan died of a heart attack last week at Yale, where he had continued to lecture long after many of the rest of us would have retired completely. Allan enjoyed his role as a science advocate, and spoke fearlessly on behalf of science and its needs. I think he reflected accurately the feelings of many scientists, and won their admiration for his defense of basic research.

When President Gerald Ford sought to create a statutory foundation for White House science advice in 1976, Congress responded with an impressively broad mandate (Public Law 94-282). The new Office of Science and Technology Policy was to advise the President (and by implication the Executive Office), coordinate science policies and budgets among federal agencies and with the private sector, build partnerships with the science community and federal, state, local, and international governments, and forecast and evaluate the federal science and technology enterprise. That is a tall order for a relatively small staff office within the White House. OSTP, however, has access to powerful resources. The challenge is not so much meeting expectations with limited resources as determining what, precisely, is the effective content of all this advice, coordination, partnershipping, forecasting and assessment? What specific things can OSTP do that will make a beneficial difference in the course and societal impact of U.S. science?

For many reasons, this turns out to be a difficult question. There is no job description for a science advisor, no one to say how to carry out the mandate from Congress or how to engage the machinery of the White House to get things done. As we begin our conversation this evening I will make a few remarks about history, and then draw your attention to two commentaries, one old, one new, that frame the challenge of science advising and give clues as to how one might go about doing it.

Thomas Jefferson launched federal science two centuries ago with his commission to Lewis and Clark. Territorial expansion and the industrial revolution continued to drive U.S. science and technology policy, such as it was, throughout the 19th century. The two World Wars and their aftermaths were primary factors in the 20th. Among these varied influences World War II stands out as a unique turning point in this history. Our attitudes today toward government's role in science were formed during the 1940's, and the institutions that support this role were largely in place by 1950, the birth date of the National Science Foundation. The larger Department of Energy laboratories were already in existence by then (under the Atomic Energy

Commission), and each of the military services had an official research office by 1951. At that time NIH had existed for 20 years. NASA and (D)ARPA came eight years later. Some reorganizations occurred after 1960, notably the metamorphosis of the AEC into the Department of Energy and more recently the creation of the Department of Homeland Security, but since 1960 the federal framework has evolved very little.

The 1940's and 50's were obviously busy years for science advisors, for whom the archetype during this period was Vannevar Bush. During the war they linked the President and top government policy makers with the nation's technical infrastructure in universities and industry. Within the White House they filled gaps in technical knowledge of the rapidly developing fields of science that would strongly influence the course of the war, transform the nation's economy in its aftermath, and revolutionize society following the disintegration of the Soviet Union in the century's last decade. The early Presidential science advisors came from a small group who had played important roles during the war, including the Presidents of Bell Labs, MIT, and Caltech, and scientists who were active in the Manhattan Project or other wartime ventures. The unambiguous focus of science advice was military preparedness.

The advisory arrangements have changed relatively little since 1950. Presidential science advisors are still mostly physicists known to each other, and national security is still an important focus of science advice (with a new homeland security angle). Given the enormous changes that have occurred in the landscape of science and the technical infrastructure of society, this invariance of the government machinery for science is mildly surprising. It speaks, perhaps, to the wisdom of the postwar policy architects, but it should also awaken a concern that the structure and practice of science policy today may diverge from the functions it needs to perform in a dynamic society.

Stability versus change is a theme of two of my favorite essays on science policy, which lie at either end of the postwar history of technological growth. At the near end is Daniel Sarewitz's 2003 essay *"Does Science Policy Exist, and if so Does it Matter?"* (available on the website of the Consortium for Science, Policy and Outcomes at Arizona State University www.cspo.org). At the far end, on the leading edge of the dramatic leap in federal science funding in the early 60's, is Alvin Weinberg's 1961 article "*Impact of Large-Scale Science on the United States*" [Science magazine vol. **134**, 161 (1961)]. This is the essay that defined and launched the concept of Big Science, but it also suggests, almost implicitly, how one ought to think about priorities for federal science. [Figures 1 and 2 show total and non-defense federal R&D since 1949 in constant 2002 dollars.]

In his 2003 essay, Sarewitz points out the remarkable stability of federal R&D funding as a fraction of the domestic discretionary budget (DDB) over four decades, except for the bulge of the Apollo moon program. Since 1961, omitting Apollo, non-defense R&D spending has fluctuated slightly above or below a constant 11% (exactly on the 30 year average of 10.8% in the current FY06 Presidential budget proposal now before Congress.)

"This stability," says Sarewitz (and now I am going to quote him extensively), "is particularly amazing given the Balkanized manner in which science budgets are determined. The first thing to note here is that there is neither a capacity nor an intent to undertake centralized, strategic science policy planning in the U.S. The seat of American science policy in the Executive Branch is the Office of Science and Technology Policy, whose director is the President's science advisor. The influence of this power has waxed and waned with time (mostly waned) [That's a plausible assumption, but too simple], but it never exercised significant influence over budgetary planning. That influence came from the Office of Management and Budget [OMB] ... which solicits budgetary needs from the many Departments and Agencies that conduct R&D, and then combines them for reporting purposes into categories that could be considered to reflect a cumulative R&D budget – but the process is largely bottom-up. The situation in Congress is even more decentralized, with numerous authorizing and appropriations committees in the Senate and House each exercising jurisdiction over various pieces of the R&D enterprise. Moreover, the jurisdiction of the authorizing committees does not match that of the appropriations committees; nor does allocation of jurisdiction among Senate committees match those of the House. Finally, the appropriations process puts S&T agencies such as NSF and NASA in direct competition with other agencies such as Veterans Affairs and Housing and Urban Development."

That is an excellent short summary of the science funding process. It omits the additional complexity of the competition science faces within its own departments, and it ignores the fact that the OMB process is not just one of combining requests from the Departments and Agencies -- that process includes significant policy decision-making and prioritizing. But it captures the decentralization and fragmentation of the process that makes the stability of the science share of the DDB pot all the more remarkable. [Figure 3 shows the stability Sarewitz is talking about. The Apollo program bulge is clearly evident.] After I showed this figure at a science policy conference celebrating Neal Lane's 65th birthday, Allan Bromley expressed surprise at this remarkable invariance.

This brief analysis suggests one answer to the question of what science advisors need to do – *engage the budget process*. In the Bush administration I have been blessed with two OMB Directors, Mitch Daniels and Josh Bolten, who included me in the policy levels of budget deliberations. In today's OSTP we set our work schedule and products deliberately to synchronize with the budget cycle. According to long time OMB staff, OSTP has unprecedented input in the budget process and the language of the budget itself. But this is beside the deeper and somewhat mysterious point of the stability of the science share of discretionary spending.

Within this relative stability of overall domestic budget market share, the fortunes of science have shifted substantially among fields. A popular graph compiled by The American Association for the Advancement of Science from OMB historical data and available at www.aaas.org (*Trends in Non-Defense R&D by Function, FY 1953–2005*) shows the three major trends that have defined postwar science: the 15 year Apollo hump starting in about 1960, the post Arab Oil Embargo energy research bulge in the mid 1970's, and the inexorable rise in the NIH budget, culminating in the five year doubling period ending in 2003. I agree with Sarewitz that "It is not only axiomatic but also true that federal science policy is largely played out as federal science *budget* policy" and it is clear from the mega-trends that the policy is impelled by societal issues external to science. [Figure 4 shows the now famous AAAS graph.]

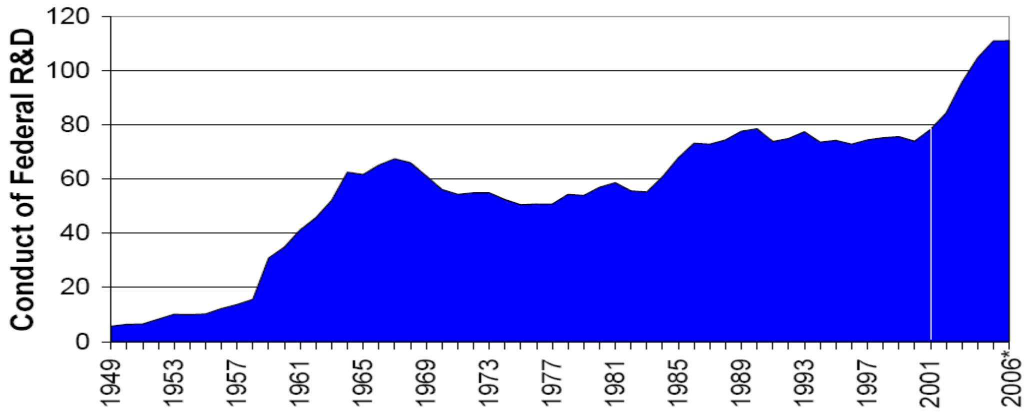
The stability of market share that Sarewitz noted began only after an abrupt adjustment following the launch of Sputnik in 1957. Federal non-defense R&D outlays rose by a factor of ten in constant dollars in the five years following 1958. This was when Alvin Weinberg wrote the second of my favorite science policy essays. Weinberg's rhetoric opposes "big" and "small" science, but his underlying principle is that the likely societal impact of different areas of science are different, and we should acknowledge this and use it as a funding criterion. For example, investments in biomedical research will probably have higher returns to society than investments in astrophysics. In Weinberg's day, the big sciences were space exploration and high energy physics. Today the need for expensive equipment in many applied fields (x-ray synchrotrons, for example, or super-computers) has blurred the significance of bigness in Weinberg's argument, but it has not diminished the need to understand the likely impact on society of different patterns of investment. Here are Weinberg's own words on the matter:

"…it is presumptuous for me to urge that we study biology on earth rather than biology in space, or physics in the nuclear binding-energy region, with its clear practical applications and its strong bearing on the rest of science, rather than physics in the Bev region, with its absence of practical applications and its very slight bearing on the rest of science. What I am urging is that these choices have become matters of high national policy. We cannot allow our over-all science strategy, when it involves such large sums, to be settled by default, or to be pre-empted by the group with the most skillful publicity department. We should have extensive debate on these over-all questions of scientific choice: we should make a choice, explain it, and then have the courage to stick to a course arrived at rationally."

I think one of the important roles of OSTP and national science advisors is to introduce such considerations into the complex process of requesting and appropriating resources, and not simply to be an advocate for everything any scientist wants to do, or to go along with societal inclinations that may be shaped, as Weinberg put it, more by public relations than by an objective assessment of importance to society. The extraordinary flowering of technology in the post WWII period has produced an unprecedented frontier of opportunity in science fields that are strongly linked to societal needs. The expense of pursuing these makes Weinberg's plea even more appropriate today than forty years ago.

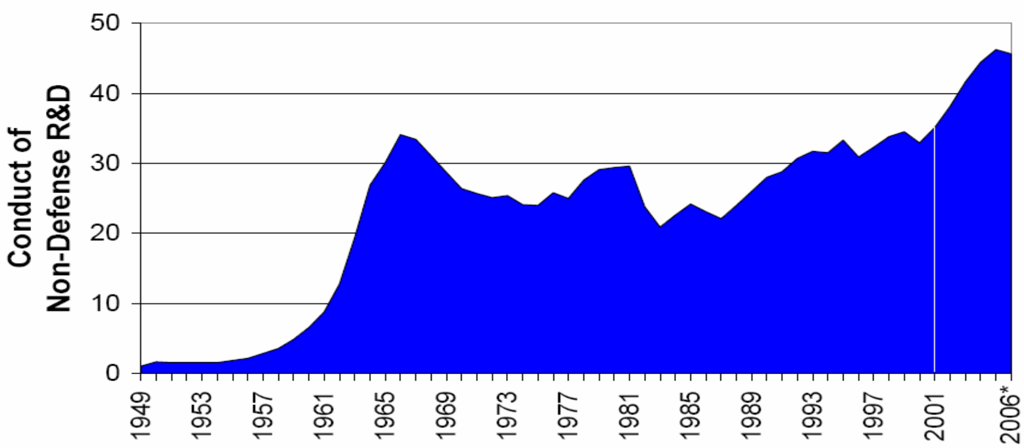
These thoughts are intended to provide context for the more detailed questions I expect Roger Pielke and the audience to ask me in the main part of this evening's program. I look forward to the discussion.

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

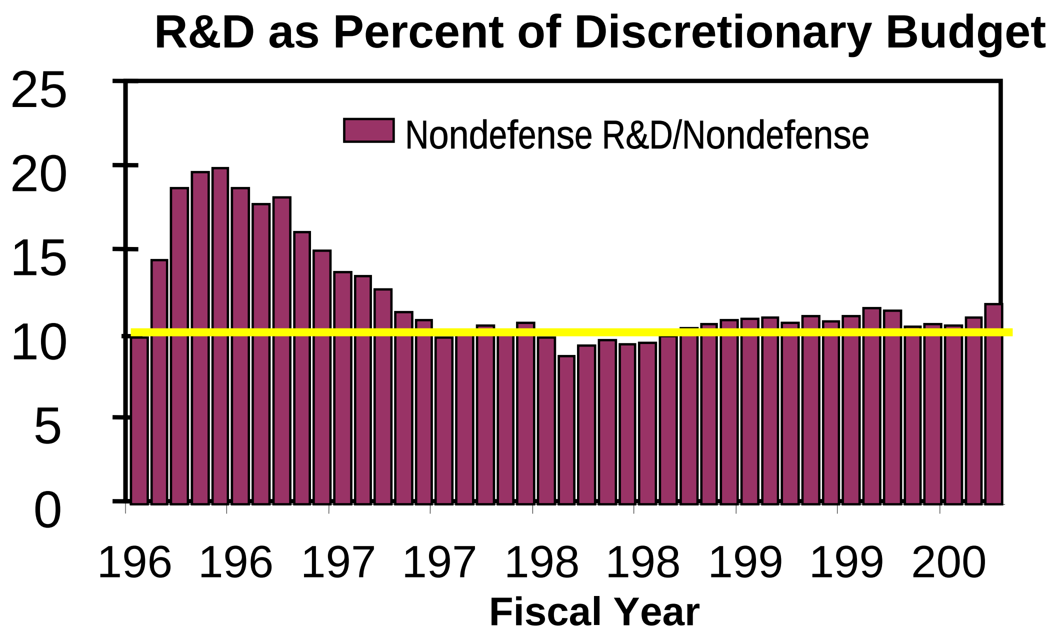


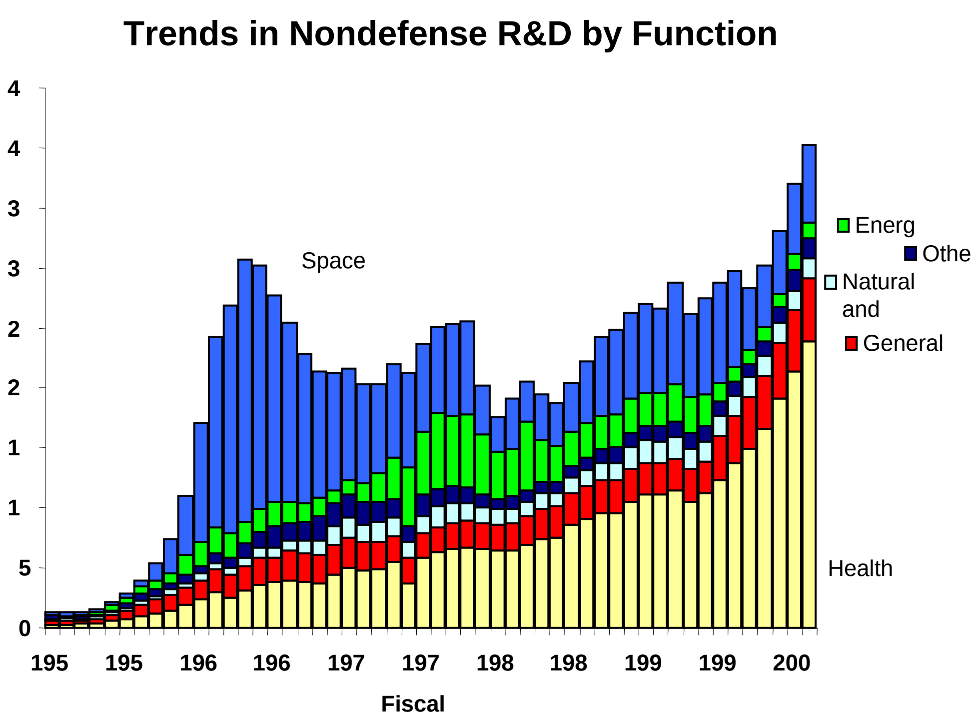
*President's FY 2006 Budget

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



*President's FY 2006 Budget


R&D as Percent of Discretionary Budget
25
20
15
10
5
0
Nondefense R&D/Nondefense
196 196 197 197 198 198 199 199 200
Fiscal Year


Trends in Nondefense R&D by Function
4
4
3
3
2
2
1
1
5
0
Space
Energ
Othe
Natural
and
General
Health
195 195 196 196 197 197 198 198 199 199 200
Fiscal