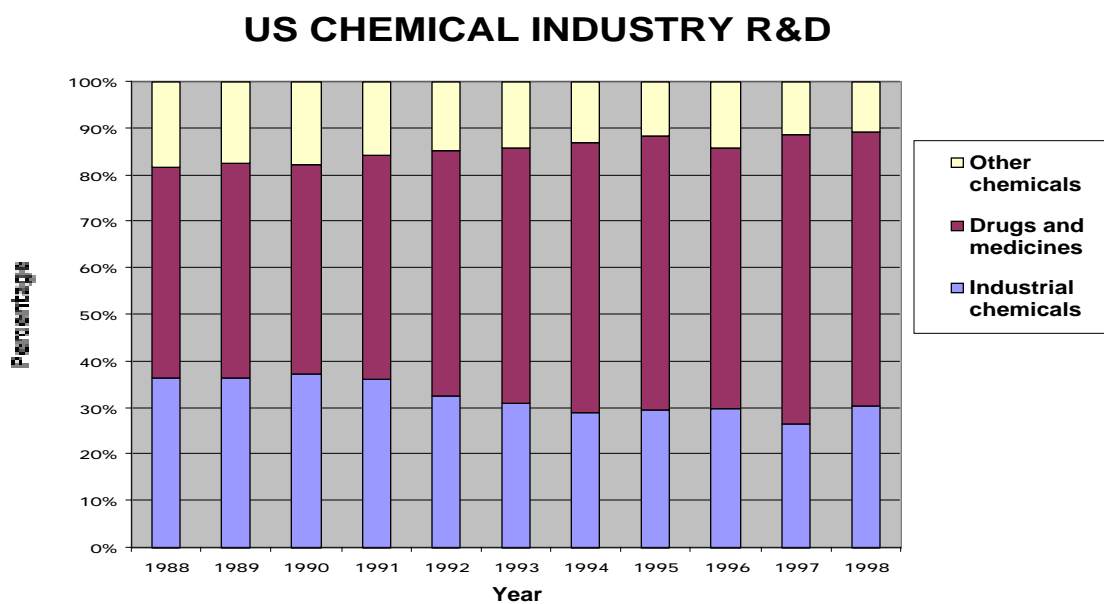


The American Chemical Industry -- A Perspective from an Academic

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The U.S. chemical industry is the world's largest manufacturer of chemical products by a substantial margin with a balance of trade surplus in excess of \$15 billion. Given its leading role in the US economy, it may be surprising to find that many academics share a sense of disquiet about its future. These feelings are brought about by the impression that the U.S. chemical industry is operating in a "harvesting mode" rather than one of sustained investment in research for future growth. Let me discuss these practices as perceived by someone outside the industry itself and outside the usual academic infrastructure that supplies talent to the U.S. chemical industry. In what follows I will draw upon "Science and Engineering Indicators," published by the National Science Board, and upon the article "Facts and Figures for Chemical R&D" that appeared in the October 25, 1999 issue of Chemical & Engineering News.

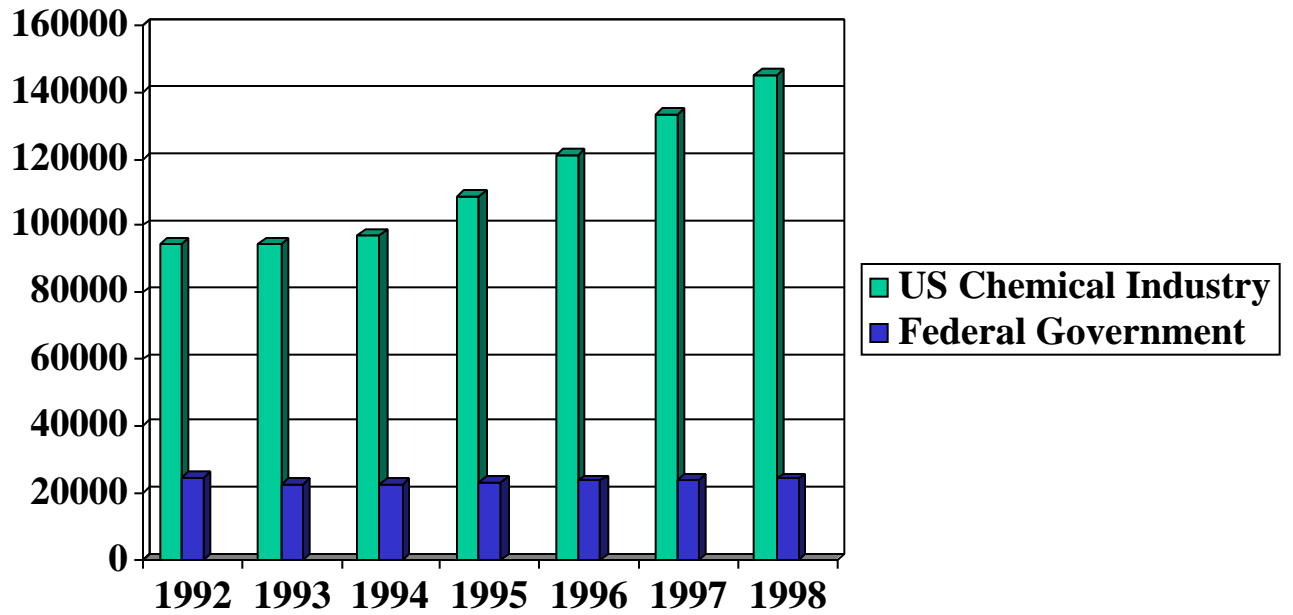
First, let me attempt a global view of the R&D expenditure in the U.S. chemical industry between 1988 through 1998, as broken down into three sectors, industrial chemicals, drugs and pharmaceuticals, and others that includes paints, fine chemicals, and consumer products. This information is shown in Vu-graph 1.



Vu-graph 1.

It is evident from Vu-graph 1 that the percentage growth is in the pharmaceutical industry. Let me also show you in Vu-graph 2 who is contributing to R&D in chemistry:

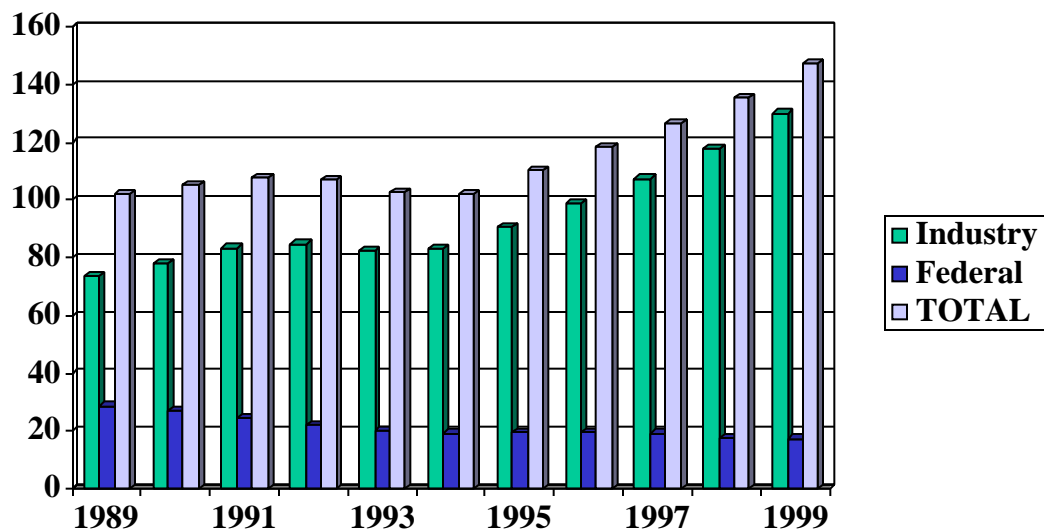
R&D Performance Trends \$, Millions



Vu-graph 2.

It is seen at once that the Federal contribution to R&D in the US chemical industry is flat and does not account for its growth. In what follows, this point will be repeated and elaborated upon.. Indeed, if you examine, as in Vu-graph 3, all industrial R&D, it is apparent that the Federal government's role is a shrinking one:

SOURCES OF INDUSTRIAL R&D FUNDS \$, Billions

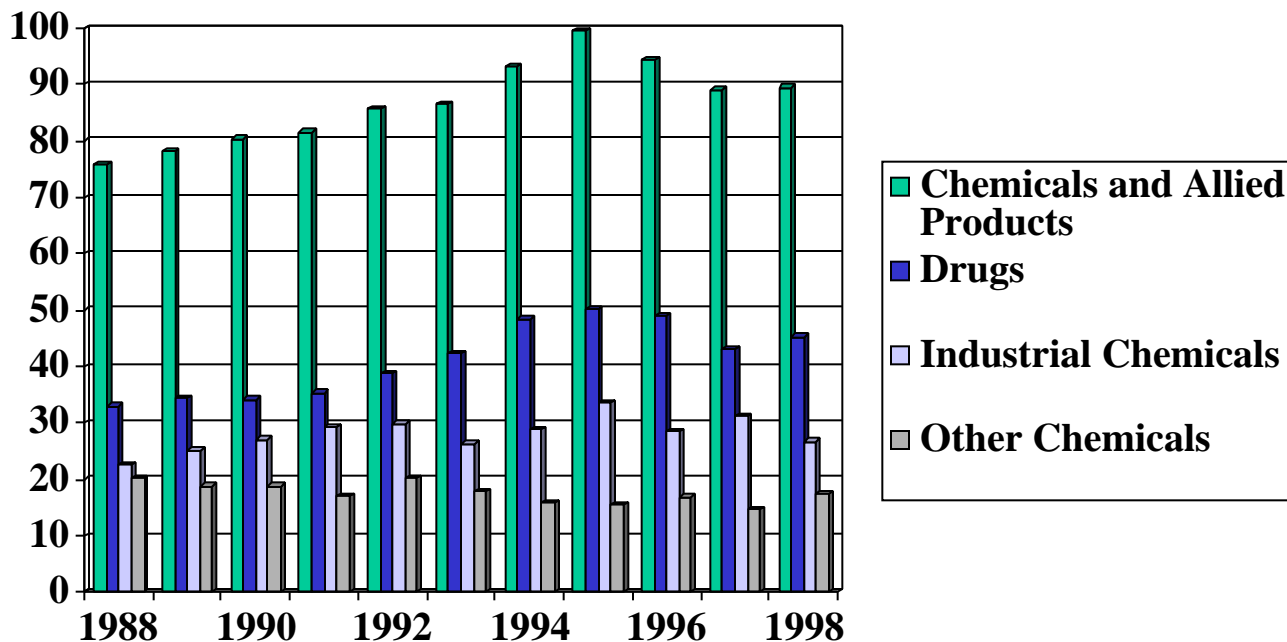


Annual Change 1989 - 1999: Industry is + **5.9 %**
Federal is - **4.9 %**; TOTAL is + **3.7 %**.

Vu-graph 3.

Let's turn next to the employment picture, which is shown in Vu-Graph 4:

R&D Scientists and Engineers in Industry (Thousands employed)



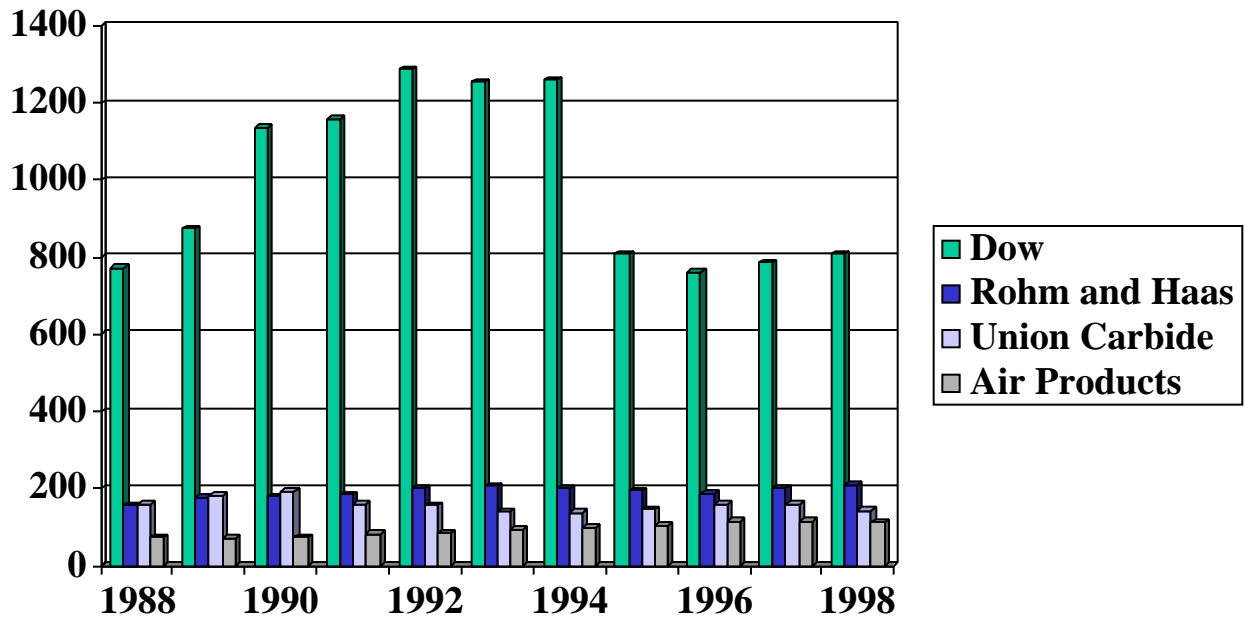
Chemical/Drug firms employ one in 10 industrial scientists.

Vu-graph 4.

This picture indicates that the number of full-time-equivalent employees in the pharmaceutical industry is rising whereas in other sectors of the chemical industry it is flat to falling. 1995 seems to have witnessed a peak in employment.

Let us ask next about how the R&D spending breaks out by chemical industry. This information is contained in Vu-graphs 5-8, which first provide specific information on the companies in three major sectors and then compares these three different sectors:

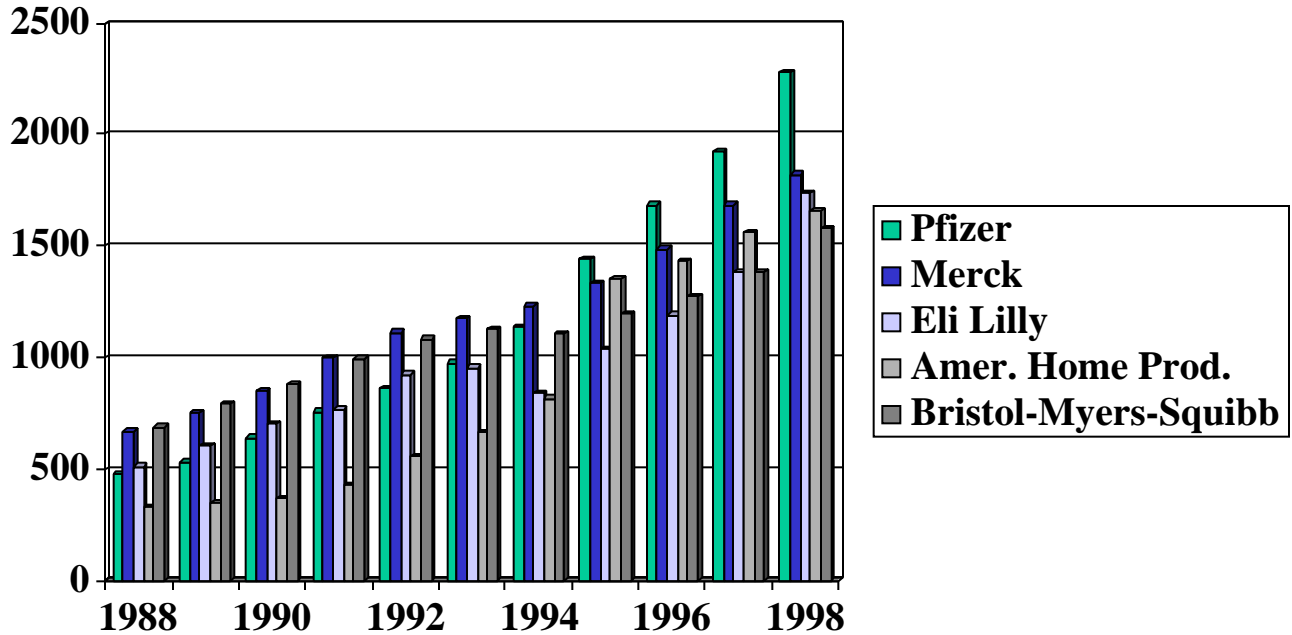
R&D SPENDING Chemical Companies; \$ Millions



1998 R&D Spending as % of Sales: Dow is 4.4 %; Rohm and Haas is 5.6 %; Union Carbide is 2.5 %; Air Products is 2.3 %.

R&D SPENDING

Pharmaceuticals; \$ Millions

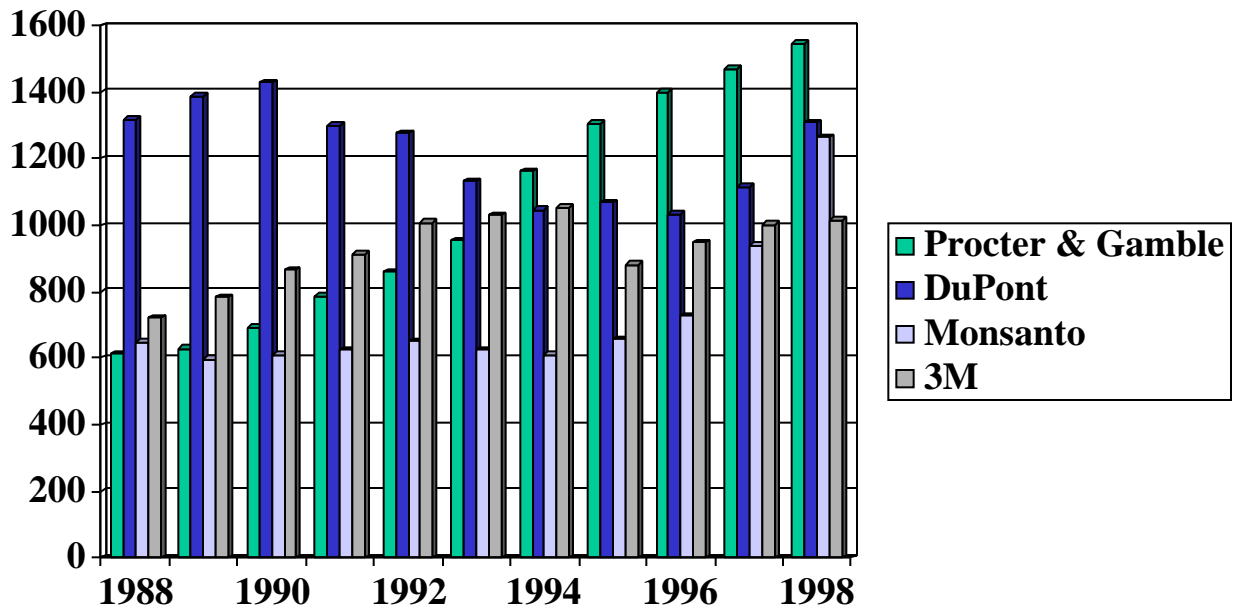


1998 R&D Spending as % of Sales: Pfizer is 16.8 %; Merck is 6.8 %; Eli Lilly is 18.8 %; Amer. Home Prod. is 12.3 %; Bristol-Mvers-Squibb is 8.6 %.

Vu-graph 6.

R&D SPENDING

Diversified Companies; \$ Millions

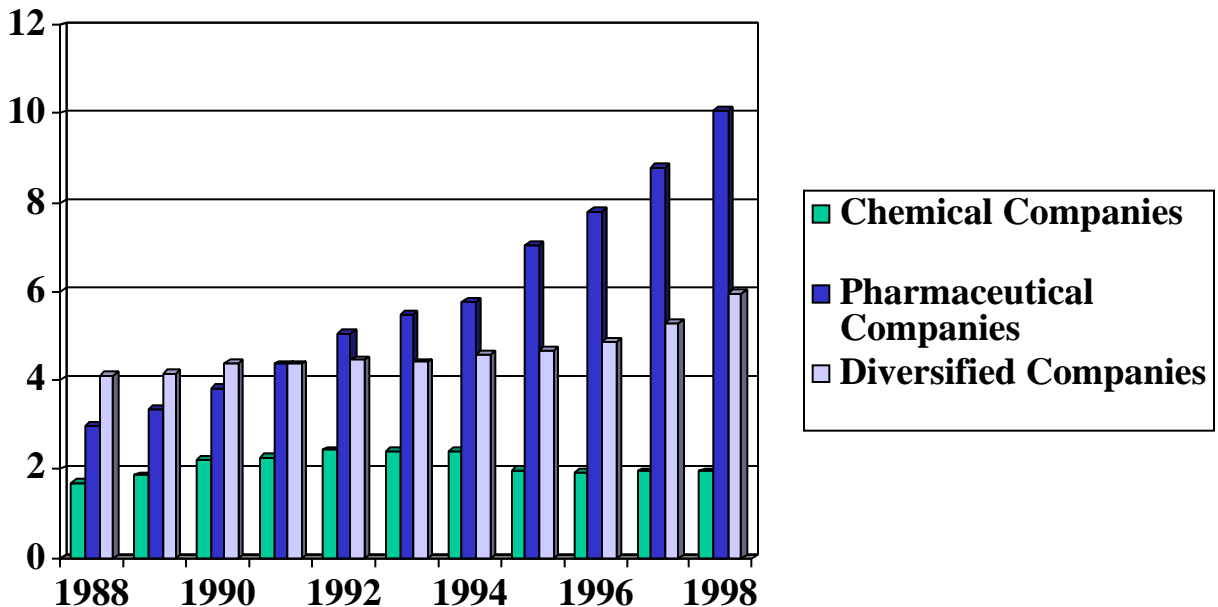


1998 R&D Spending as % of Sales: Procter & Gamble is 4.2 %; DuPont is 5.3 %; Monsanto is 14.6 %; 3M is 6.8 %.

Vu-graph 7.

R&D SPENDING

Chemical Industry Segments; \$ Billions



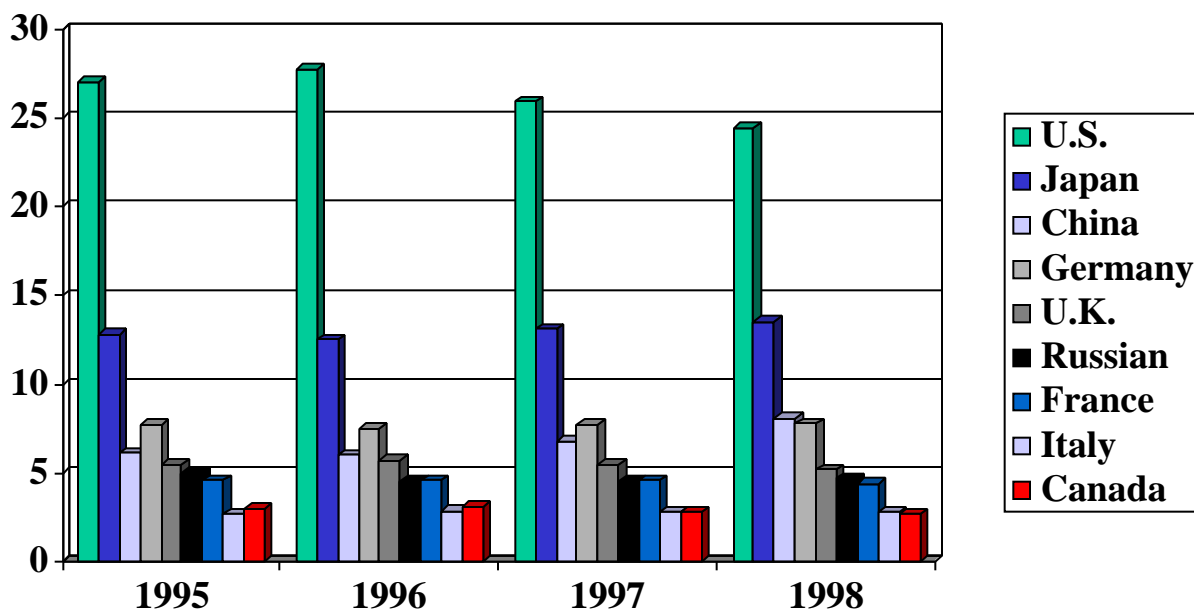
1998 R&D Spending as % of Sales: chemical companies are 3.5 %; pharmaceutical companies are 11.3 %; diversified companies are 5.3 %.

Vu-graph 8.

From this detailed information I reach the conclusion that the pharmaceutical companies are enjoying healthy growth with a significant investment being returned into R&D, but the chemical companies are having stagnant growth in R&D, with an investment that parallels other commodity industries. The diversified chemical companies are intermediate in behavior with a real increase in R&D investment occurring. When your company becomes a supplier of a commodity, then your business is driven by the bottom line and questions of cash flow become quite important. At the margin it is always easy to cut back on R&D expenditures because their influence is delayed in time. The market drives these realities. It is not that executives of companies facing this situation do not appreciate the benefits of research and development. It is that the market does not permit such action. How strikingly different this behavior is in comparison to start-up biotech concerns, for example.

Do we really need this research? Vu-graph 9 shows where the publications in the chemical sciences are coming from:

Origin of Chemical Literature (% of total papers)



The U.S. is dominant but declining while Japan and China are rising.

Vu-graph 9.

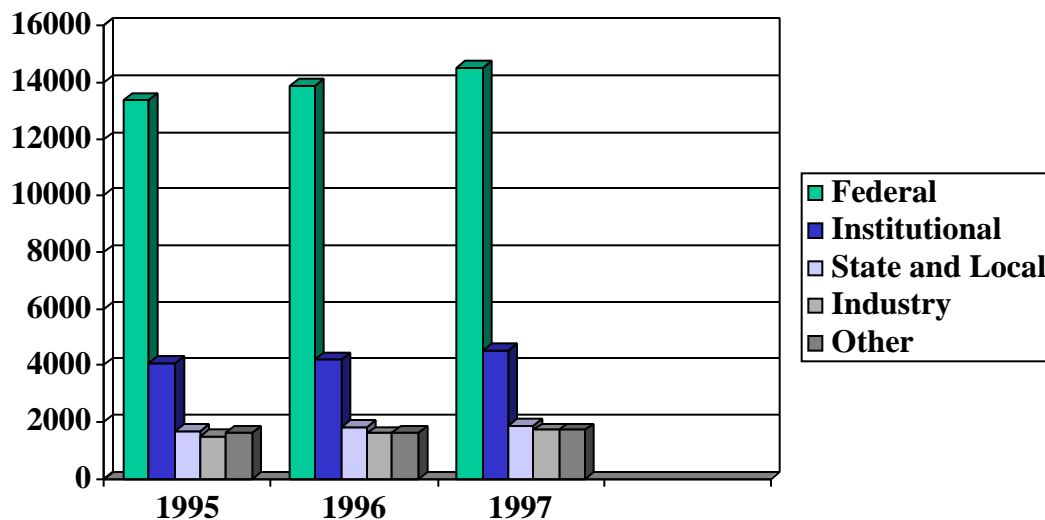
The US has a commanding lead over any other country in the output of published papers, but Japan and China are growing in strength and their combined output is almost that of the US. Moreover, the US dominance is slipping, as Vu-graph 9 shows. The trend cannot give comfort to the US chemical industry about who is inventing and discovering the future. Are our US universities letting us down?

Indeed, I do not have hard facts to back up this next statement, just anecdotal information acquired by visiting many places and talking to many people. Increasingly, the US chemical industry is relying upon their basic research to be done elsewhere as their own time horizon shrinks as to what constitutes a long-term investment in R&D. Not only does more D

occur than R at US chemical industries but the expectations of when a return on the spent funds will be seen has dramatically shortened. Chemical industry R&D increasingly is tied to product lines and businesses. Although industry R&D may be accounting for a larger share of total R&D in the chemical industry, it is not being directed to developing the innovations that will keep the US chemical industry competitive in the years to come. Moreover, past history teaches us that innovation tends not to thrive so well in larger, more bureaucratic structures, which often result from mergers and acquisitions as the chemical industry, particularly the pharmaceutical industry, consolidates. If someone is to take up the slack, then it might be expected to be US universities.

Vu-graph 10 shows how R&D efforts at US universities are funded:

Source of Academic R&D Funds
\$ Millions



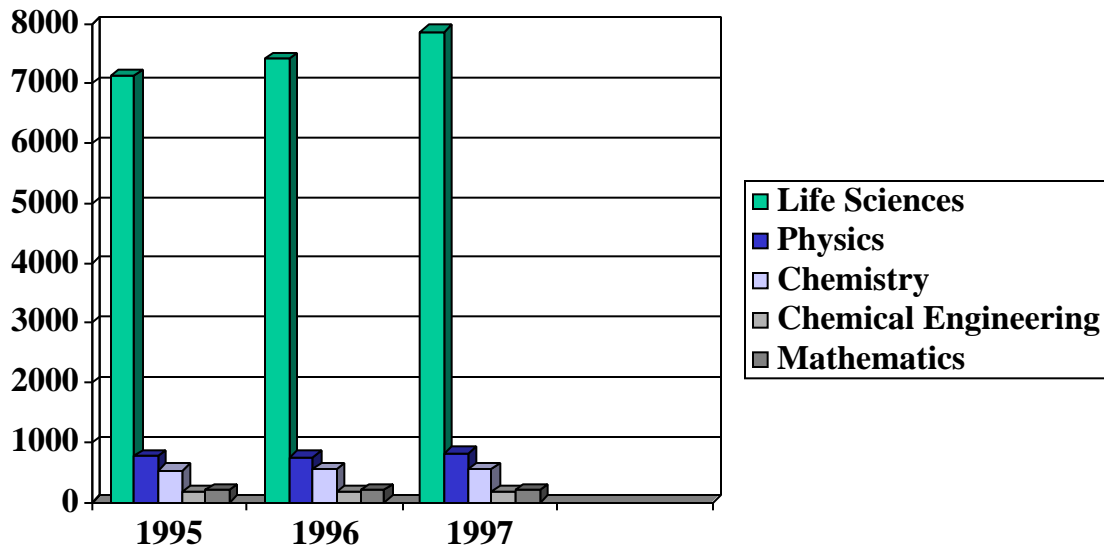
The federal government supplies almost 60 %, the schools almost 20 %, and industry, state and local government, and others about 7 % each.

Vu-graph 10.

What seems surprising about this Vu-graph is that US universities contribute so much compared to other sources. Indeed, their contribution is one-third of that of the Federal government, whereas it is common to hear it said that the US universities are taking a “free ride” at the expense of the US taxpayer. The Federal government contribution is actually just slightly under 60 % of the total.

So how well is the Federal government doing in supporting this enterprise?
Vu-graph 11 shows that chemistry is not keeping up with other fields:

Federal R&D at Universities \$, Millions

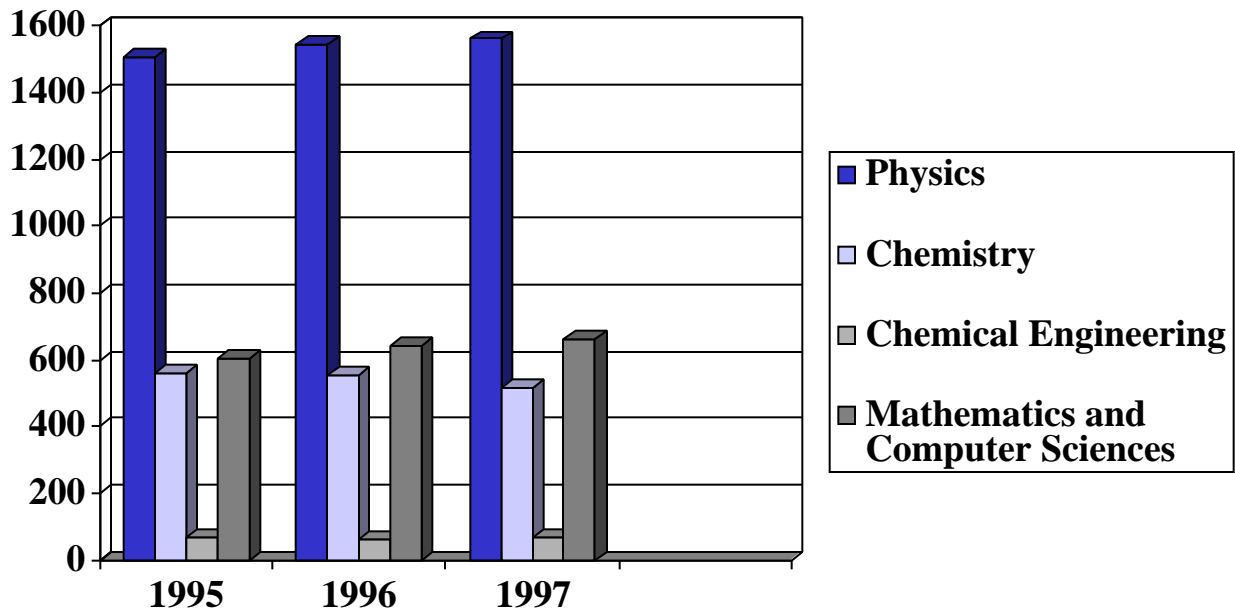


From 1996-1997 the annual change in chemistry was **0.0 %**, in chemical engineering was **-3.5 %**, and in the life sciences was **6.3 %**.

Vu-graph 11.

Still more distressing, as shown in Vu-graph 12, is what is happening in basic research – and what is happening in what is called applied research (Vu-graph 13) is no cause for rejoicing either:

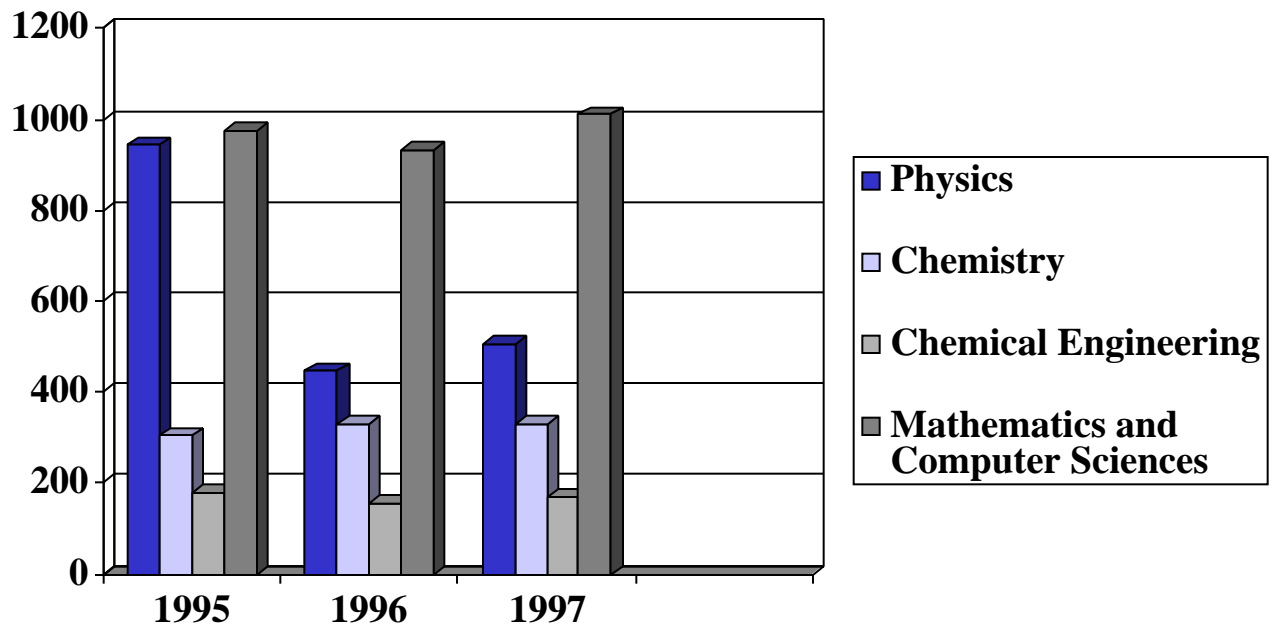
Federal Obligations for Basic Research; \$ Millions



In 1996-97 the annual change for the life sciences was 4.7 %, but - 6.0 % for chemistry.

Vu-graph 12.

Federal Obligations for Applied Research, \$ Millions



In 1996-97 the annual change for the life sciences is **5.3 %** but for chemistry is **- 0.8 %**.

It would seem then that the only reasonable hope we have of keeping the US chemical industry from increasingly sliding into a commodity status, such as what has happened to the US steel industry, is to be the leading innovator. If fundamental innovations are no longer to come from industry but rather from universities, then we face a painful realization that we have been pursuing a not very prudent course of underinvesting in university chemistry R&D. The course we have been on can be explained in part by permitting an imbalance to develop between how we support the life sciences and the physical sciences, particularly the chemical sciences. Another part has been our reluctance as a Nation to come to grips with the realization that so much of our economy is traceable to technological innovation that goes hand and hand with scientific training and inquiry. It is not too late to do something about this situation. It will require the US chemical industry to realize that such an investment is very much in its self interest and to call for more Federal R&D at US universities as part of our investment in the future of our Nation.