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A Letter to Members

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Changing Partners: The Mellon Institute, Private Industry, and the Federal Patron

JOHN W. SERVOS

In 1966, when plans were announced for the merger of the Mellon Institute and Carnegie Institute of Technology, architects of the merger forecast that "two plus two would equal five." By joining the Mellon Institute's facilities, endowment, and traditions of postdoctoral research to the faculty, plant, and graduate programs of neighboring Carnegie Tech, an institution would be created that would make Pittsburgh as famous for science as for steel and thereby restore that city to the forefront of technological innovation. Federal research dollars, attracted by powerful science departments, would underwrite this renaissance. Predictably, publicists looked east and west to define the new Carnegie-Mellon University; it would soon be ready, wrote one editor, "to move into the Olympics of technical education with schools like Massachusetts Institute of Technology and California Institute of Technology."[1] The official rhetoric exemplified two assumptions shared by many scientists and science administrators in the postwar era: new technologies often flow from scientific research that is free of practical goals, and federal money is instrumental to scientific, institutional, and civic development.

These assumptions were not shared by the founders of the Mellon Institute. Conceived on the eve of World War I, the Mellon Institute had, during its first forty years, embodied many of the values of the generation that had made Pittsburgh a 20th-century workshop of the world. Although housed in a magnificently appointed and many-columned temple, the Mellon Institute had been built, not to celebrate

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[1] *Pittsburgh Press*, September 16, 1966, p. 22. See also "Carnegie University: New Institution Emerging in Pittsburgh," *Science* 155 (1967): 673–76.

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disinterested research, but to solve the immediate problems of industry. It had valued patents over publications and product improvements over citations in scientific journals. Financed by the bankers who had underwritten Pittsburgh's expansion, it was run by trustees and managers who believed in a kind of science that could both serve private enterprise and support itself by doing so.

Although the name of the Mellon Institute survived the merger with Carnegie Tech, the institute's program and values did not. Its dissolution, however, did not commence in 1966; rather, the decision to join the Mellon Institute to Carnegie Tech came at the end of more than a decade of erosion and soul-searching. This article traces the decline of the Mellon Institute during the postwar era. The story is worth recounting, not only because the institute was an important and influential experiment in the organization of industrial research, but also because its history affords us entry into debates that affected more than one institution in the postwar years: debates between proponents of applied research and basic research and between strategists who looked to government for the resources to finance science and those who looked to corporations.

Most important, the history of the Mellon Institute offers us another perspective on the sea change that affected science and its institutions in postwar America. It has become a truism to say that federal patronage transformed the practice of science in the United States during and after World War II. Massive federal outlays for research and science education altered the expectations of scientists, the nature of their equipment, and the scale and character of their institutions. Recent historical scholarship has begun to give us some appreciation of the dimensions and significance of this revolution.[2] As yet, however, we possess few studies of how scientific institutions that were built in earlier eras made the passage to the postwar world. Such inquiries are important if we are to grasp the many and diverse ways in which changes

[2]Among the most valuable of recent works on the effects of federal patronage on postwar science are Walter A. McDougall, . . . *the Heavens and the Earth: A Political History of the Space Age* (New York, 1985); Thomas J. Misa, "Military Needs, Commercial Realities, and the Development of the Transistor, 1948–1958," in *Military Enterprise and Technological Change: Perspectives on the American Experience*, ed. Merritt Roe Smith (Cambridge, Mass., 1985); Paul Forman, "Behind Quantum Electronics: National Security as Basis for Physical Research in the United States, 1940–1960," *Historical Studies in the Physical and Biological Sciences* 18 (1987): 149–229; Rebecca S. Lowen, " 'Exploiting a Wonderful Opportunity': Stanford University, Industry and the Federal Government, 1937–1965" (Ph.D. diss., Stanford University, 1990); and Stuart W. Leslie, *The Cold War and American Science: The Military Industrial-Academic Complex at MIT and Stanford* (New York, 1993).

in patronage altered the values of scientists and the structure of their enterprise. This article is such a case history.

Described both as "the drab and slut of industrialism" and as a benefactor of mankind, the Mellon Institute brought to its merger with Carnegie Tech a history more interesting than either phrase suggests.[3] Founded in 1913, the Mellon Institute resulted from the conjunction of a chemist's dreams, financiers' money, and an educator's ambition. The chemist was Robert Kennedy Duncan (1868–1914), a sometime journalist and teacher who parlayed a knack for phrase making and a familiarity with industrial chemistry into a short but lively career as a writer, university professor, and institution builder. The financiers were Andrew W. Mellon (1855–1937) and Richard B. Mellon (1858–1933). Already the owners of banks, insurance companies, coal fields, and shipping and traction companies, as well as major investors in both the Aluminum Company of America and Gulf Oil Company, the Mellons were well on the way to eclipsing the wealth of Pittsburgh's most famous magnate, Andrew Carnegie. The educator was Samuel B. McCormick (1858–1928), a chancellor trying to bring his university into the age of research but still keeping track of $10 donations in a vest-pocket ledger.

If subsequent recollections are to be trusted, Duncan conceived the idea that would bring together this unlikely ensemble while on a tour of Europe in 1906.[4] Reflecting on the efficiency and inventiveness of German industry and the wastefulness and backwardness of American manufacturing firms, Duncan experienced a kind of epiphany. The fundamental reason for the disparity, to his eye, was the greater cooperation evident in Germany between businessmen and scientists, especially chemists. American businessmen, out of ignorance and greed, had sought advantage by manipulating tariffs, by intrigue to stifle competition, and by shamelessly exploiting the nation's abundant raw materials. Germany's more enlightened industrialists had instead harnessed knowledge to their service, improving traditional processes by drawing on the human and scientific resources of the academy. The merits of these strategies, Duncan asserted, were becoming clear: German products were breaching America's tariff walls while American consumers, fed up with high prices and shoddy merchandise, were rising in rebellion. The Pure Food Law and antitrust legislation were

[3]Harvey O'Connor, *Mellon's Millions: The Biography of a Fortune* (New York, 1932), p. 247; Andrew W. Mellon, "The Dedication of the Mellon Institute," in *Addresses at the Exercises and Science Symposium during the Dedication of the New Building of Mellon Institute* (Pittsburgh, 1937), p. 8.

[4]Raymond F. Bacon, "The Object and Work of the Mellon Institute," *Journal of Industrial and Engineering Chemistry* 7 (1915) (reprint), p. 1.

signs of public unrest and symptoms of greater upheavals to come—unless, that is, American manufacturers embraced the methods of their German rivals.[5]

Small manufacturers and some large firms were, Duncan believed, ready to accept the gospel of research, but they simply did not know how to use modern knowledge. Their factories were run by foremen wedded to traditional shop practices; their front offices were controlled by managers "concerned, first of all, with business, *i.e.*, the making of money, and only secondly—and often distinctly at that—with the true manufacturing function, which consists in making the best thing at the cheapest price."[6] Chemists who entered factory practice found a role like that "of a cultured governess in the home of a codfish aristocracy." Manufacturers had too little patience to wait the typical "two, three, or even five years" it took chemists to prove their value, they burdened them with routine analytical and trouble-shooting chores, and they gave far too much power to foremen with a stake in preserving the status quo.[7] No less hostile to change than the shop culture of the factory floor was the academic culture of the universities. Not only were academics out of touch with up-to-date industrial practice, American universities were dominated by an ethos of pure science that artificially divided knowing and doing. "The student in college is currently and traditionally taught that Science should be served for her own sake, that causing her to subserve utilitarian needs sullies her beauty, and that obtaining material rewards through her degrades her devotee."[8] Rather than dig trenches between science and practice, educators should be building bridges.

Duncan's analysis, but for the vigor of its phrasing, was hardly remarkable for his time. He belonged to a generation of American industrial chemists and engineers who had seen firsthand the disparities between the workshops of Germany and America and who perceived benefits for their profession, their clients, and the public in reducing those disparities. What set him apart from most, however, was the specificity of his recommendations. Not only did he call for bridges, he provided blueprints. A new kind of institution would be necessary to bring together the manufacturer and the chemist, industry and the university. This institution was the industrial fellowship.

[5]Robert Kennedy Duncan, "Temporary Industrial Fellowships," *North American Review* 185 (1907): 54, "Speech at Residence of Dr. McCormick," October 17, 1910, University of Pittsburgh Archives (hereafter cited as Pitt), FF 63, "On Industrial Fellowships," *Journal of Industrial and Engineering Chemistry* 1 (1909) (reprint), p. 2.

[6]Robert Kennedy Duncan, *The Chemistry of Commerce* (New York, 1907), pp. 3–4.

[7]Ibid., p. 11, and Duncan, "Speech at Residence of Dr. McCormick," p. 6.

[8]Duncan, *Chemistry of Commerce*, p. 8.

The idea was seductively simple. Universities had scientists with knowledge that could be useful to industry and offered conditions well suited to research; they lacked an intimate and up-to-date understanding of manufacturers' problems and the money to pursue industrial problems past the laboratory stage. Industrial firms had cash and well-defined problems; they lacked scientific talent and traditions of research. By joining the manufacturer's money and proprietary knowledge to the academy's expertise and research ethos, both parties might benefit. Industrial fellowships would provide the nexus. Business firms, according to Duncan's plan, might establish contracts with universities under which the firms would give promising students research topics and stipends in return for rights to any patents or other useful knowledge that might result from their work. Fellows would benefit from having access to both the sponsor's cash and its proprietary knowledge and might find career opportunities in the sponsor's firm. Sponsors would be able to secure the benefits of scientific research without making large capital outlays or permanent commitments. Universities would find new money for equipment and the expansion of graduate programs. They would also be serving the general public by improving the efficiency of American industry and the quality of its products. To ensure that consumers would, in fact, realize such benefits, a fellow would be obliged to prepare a full report on his research; three years after the expiration of his fellowship, the university would be at liberty to publish the report "for the use and benefit of the people." The university's role as a party to the contract would, in Duncan's opinion, ensure that the interests of the public would be represented and protected.[9]

First described in an article in the May 1907 issue of the *North American Review*, Duncan's industrial fellowship plan won wide publicity during the following three years in part because of Duncan's considerable skill at self-promotion and in part because his ideas resonated with so many of the themes and anxieties of his era. Indeed, Duncan offered comfort to a broad spectrum of readers: businessmen frightened by German competition; conservationists worried about the wasteful exploitation of natural resources; scientists interested in finding new markets for their services; educators seeking new resources for graduate schools; consumers disgusted with the tactics of big business and the shortcomings of its products; progressives eager to improve the efficiency of American institutions; and all those convinced that impartial experts could make those institutions work for the public welfare. By the time the article appeared, Duncan had already secured the cooperation

[9]Ibid., pp. 250–51, and Duncan, "On Industrial Fellowships," p. 3.

of the chancellor of the University of Kansas, where Duncan had become professor of industrial chemistry, and lined up his first customer; by 1909 eight sponsors were supporting work on projects as diverse as finding new uses for waste buttermilk and saving fabric wear in laundering.[10]

The fellowship plan did not prove to be as perfect a vehicle for harmonizing interests as Duncan had imagined. Sponsors sometimes proved reluctant to see the results of their fellowships published and secured additional concessions to protect their investments. The university's administrators found fellowships far more costly than they had imagined and insisted on overhead fees and contributions from fellows in the classroom. Colleagues quickly grew uneasy with the narrowly conceived research that flourished under the scheme and segregated Duncan and his fellows in a new department of industrial research. And critics soon appeared who questioned the wholesomeness of any arrangement that made a state university the partner of private firms.[11]

By 1910, Duncan had nearly exhausted the possibilities at the University of Kansas. When, in the spring of that year, Samuel B. McCormick invited Duncan to discuss the creation of a fellowship plan at the University of Pittsburgh, Duncan must have felt relief. Pittsburgh offered far more opportunities for industrial contacts than Lawrence. Not just the center of America's iron and steel industry, it was also a leader in the production of tin plate, firebrick, coke, glass, electrical equipment, paint, petroleum, and nonferrous metals. It also quickly became clear that McCormick's invitation was, like much that happened in Pittsburgh, the idea of the brothers Mellon.[12] Their wealth and influence could guarantee Duncan the means necessary to transform his small experiment into an enterprise with national impact.

Although known neither for book learning nor for philanthropy, Andrew W. and Richard B. Mellon did have a sure business judgment and far more imagination than their detractors acknowledged. Indeed, an openness to novel ideas had led them to many of their most lucrative investments. In 1889, the Mellon brothers, of whom Andrew was clearly the leader, had provided capital to the Pittsburgh Reduction Company, then struggling to find the resources to develop Charles Martin Hall's electrolytic technique for refining aluminum. Six years later, they provided similar support to E. G. Acheson, the inventor of the process for producing carborundum. These investments gave the Mellons major

[10]H. J. Haskell, "Robert Kennedy Duncan," *American Magazine* 71 (1910–11): 461–62; Frank Strong, *Report of the Board of Regents of the University of Kansas for the Biennium Ending June 30, 1909* (Topeka, Kans., 1908), pp. 20–21, 27, 81.

[11]Duncan, "Speech at Residence of Dr. McCormick" (n. 5 above), pp. 20–23.

[12]Andrew W. Mellon, "The Dedication of the Mellon Institute" (n. 3 above), pp. 7–9.

stakes in two of the fastest-growing companies of the early 20th century: Alcoa and the Carborundum Company. By putting up money to sustain an oil-drilling venture on the Texas Gulf plain at the turn of the century the Mellons opened up the massive Spindletop oil field and obtained a controlling interest in what would become the Gulf Oil Company. Seeing potential markets for the volatile by-products of coke distillation, the Mellons later bought American rights to the coke ovens of the German inventor Heinrich Koppers and secured dominance in what would become another major industry.[13]

These investments, which would prove even more important to the family's wealth than its banking business, testified both to the Mellons' willingness to take modest risks and their interest in technologically sophisticated ventures. Lacking in scientific training, they nevertheless had confidence in the wealth-generating possibilities of new technologies and had made a habit of associating themselves with inventors and scientists of a practical bent. By 1910, these investments had begun to show significant returns, although in each industry sustained growth depended on the ability to maintain patent positions, exploit new opportunities, and fend off competition. The Mellons' deep pockets and political influence could go a long way toward insulating family enterprises from competition, and the Mellons exploited these advantages with a skill that critics found diabolical. But the problems of scaling up production, improving efficiency, and opening up new markets called for technical expertise.

Some firms in analogous situations had begun to invest in experiment stations and research laboratories; others relied on academic consultants or profit-making vendors of research. The Mellons were familiar with these strategies but generally made do with the practical experience of partners or trusted employees. Research at Alcoa, for example, remained the bailiwick of Charles Martin Hall long after the needs of the company outgrew his capacities.[14] The Mellons were often willing to support bright young men who had demonstrated promise, if only on a small scale; but they were skeptical of academics, wary of propositions that demanded cash prior to showing any results, and uneasy with bureaucracy.

[13]For accounts of these and other Mellon investments, see O'Connor's relentlessly critical *Mellon's Millions* (n. 3 above) and David E. Koskoff's more mellow *The Mellons: The Chronicle of America's Richest Family* (New York, 1978). On the electrochemical industry at the turn of the century, see Martha Moore Trescott, *The Rise of the American Electrochemical Industry, 1880–1910* (Westport, Conn., 1981); on Alcoa, see George D. Smith, *From Monopoly to Competition: The Transformations of Alcoa, 1888–1986* (New York, 1988).

[14]Margaret B. W. Graham and Bettye H. Pruitt, *R&D for Industry: A Century of Technical Innovation at Alcoa* (New York, 1990), p. 73.

Although Duncan was an academic who, according to one journalist, looked like a poet and talked like a novelist, he was able to show results. At Kansas he had demonstrated that corporations were willing to buy his product; some sponsors had secured marketable products from his work.[15] His warnings about the need for research to produce sustained growth reverberated with the Mellons' mounting experience in high-technology industries. His fellowship plan offered sponsors flexibility and low fixed costs. Management was left to the University of Pittsburgh; expenses would be spread across the entire set of fellowship sponsors and not borne solely by Mellon family enterprises. The scheme might assist other Pittsburgh industries to which the Mellons were bankers; it might also introduce business values and procedures into the deficit-ridden University of Pittsburgh—long a project of Andrew Mellon. To be sure, Duncan's diatribes against business intrigue must have been a bit jarring to the Mellons, but who was better prepared to understand them than these expert practitioners of the art?

When asked if there was a link between his passion for art and his business career, Andrew W. Mellon once said that art had taught him a great deal about business. It was his practice to study a picture carefully in his home for some time before buying it. "If the meaning of the whole canvas finally comes clear," he said, "and the top and the bottom and the corners, as well as the center of the picture, all contribute toward a single meaning, and then if I like the meaning, I am apt to buy the picture. Don't you see that a business project is like that? The whole thing is put in front of you. You think it over again and again. There are always corners and tops and bottoms, as well as a center, in a business problem. The important thing is to see the whole project before you go into it. Paintings taught me that."[16] Mellon and his brother liked the portrait that Duncan had painted.

Duncan's fellowship plan appealed no less to Samuel B. McCormick than to the Mellons. Long eager to stimulate the Mellons' interest in the University of Pittsburgh, he recognized an opportunity when he saw one. Duncan might or might not be the architect of cooperation between American industries and American universities, but he could give Pitt access to the Mellons' millions. After some negotiation, McCormick and Duncan struck a deal in September 1910. In return for an appointment as head of a new department of industrial research and other assurances of support, Duncan agreed to deploy his

[15]Haskell (n. 10 above), p. 461. One of his fellows at Kansas had, for example, isolated and cultured the bacterium necessary for the production of salt-rising bread for the National Association of Master Bakers.

[16]Affidavit given by John G. Bowman, November 10, 1939, Pitt, FF 51.

persuasive powers on behalf of the university both in meetings with Pittsburgh's moguls and in articles in prominent literary magazines.[17]

The Mellons' commitment to the fellowship idea grew rapidly after Duncan arrived in Pittsburgh. Although the Mellons initially promised a modest $5,000 to renovate an old building for Duncan's use, within months of his arrival they had increased their pledge to $12,000 for a new timber structure to house twenty-five fellows.[18] Two years later, with the wooden laboratory filled to capacity, Duncan successfully petitioned the Mellons for funds to build, equip, and maintain a new and more capacious laboratory. This stone-and-brick structure, which today houses part of the physics department of the University of Pittsburgh, cost $250,000 when finished, boasted a $20,000 library and $60,000 worth of equipment, and enjoyed the Mellons' promise of annual contributions of up to $40,000 for maintenance.[19] Named the Mellon Institute of Industrial Research and School of Specific Industries of the University of Pittsburgh, the new institution was designed to house the work of sixty industrial fellows and to serve as a nucleus for the development of graduate study and research at the University of Pittsburgh. Perhaps without intending it, the Mellons' modest provisions for Duncan's start-up costs had evolved into philanthropy.

Duncan, who died in 1914, did not live to see the new building completed, nor did he survive to witness a long series of disputes that developed between the growing cadre of Mellon fellows and their colleagues in the university's academic departments. Although Duncan and McCormick had hoped to see industrial fellows take an important role in building up Pittsburgh's small graduate school, and especially its Department of Chemistry, members of the university community soon discovered that most of the benefits of cooperation flowed one way. Mellon fellows took graduate degrees at the university but paid no tuition and met degree requirements set not by the university but by the directors of the Mellon Institute; their building stood on the university's land, but the institute paid no rent, shared none of its revenues, and failed to meet commitments to supply the university with instructors.[20]

[17]Robert Kennedy Duncan to S. B. McCormick, September 21, 1910, Pitt, FF 63.

[18]S. B. McCormick to A. W. Mellon, March 8, 1911, Pitt, FF 63.

[19]Robert Kennedy Duncan to A. W. Mellon, January 27, 1913, Pitt, FF 63; "Articles of Agreement between Andrew W. and Richard B. Mellon and the University of Pittsburgh," March 1, 1913, A. W. Mellon Charitable Trust Papers, University of Pittsburgh Archives (hereafter Mellon Trust Papers), "Mellon Institute of Industrial Research" file; Raymond F. Bacon, "Progress in Industrial Fellowships," *Journal of the Franklin Institute* (November 1914), p. 623.

[20]Correspondence documenting the frictions between the university and the Mellon Institute may be found in Pitt, FF 41 and FF 63.

While hostility between Mellon and university personnel festered, the administration of the Mellon Institute became more and more committed to the interests of its industrial sponsors. When Duncan died, he was succeeded as director by Raymond F. Bacon, a protégé who shared Duncan's enthusiasm for industrial research but lacked his suspicion of businessmen and commitment to the university. Under Bacon, the Mellon Institute began a transition from being an experiment in industrial-academic cooperation to being a nonprofit version of a private consulting firm. Sponsors were given the right to veto fellowship candidates who were found unacceptable and the university's role in overseeing contracts was gradually diluted. New language was inserted into contracts that prohibited fellows from revealing any information about the processes of the sponsor or the sponsor's costs of manufacture in the fellow's final "public" report on his research. This report, which Duncan had seen as protecting the public from private interests, now could discuss only statements of the discovery of "scientific fact."[21]

As the institute's business swelled, one by one the lines linking it to the University of Pittsburgh parted. When an exhausted McCormick resigned as chancellor in 1920, his successor, John G. Bowman—perhaps the only university president to have on his vita a title like *Happy All Day Through*—quickly cut the knot between the Mellon Institute and the chemistry department.[22] This action was prelude to a fuller and more formal separation of the two institutions in 1928, when the Mellon Institute was chartered as an independent, nonprofit corporation by the State of Pennsylvania. Although independence represented a renunciation of the reasoning that had led to the creation of the institute, the change aroused hardly a murmur of dissent or controversy. After seventeen years of bickering and frustration, all parties had come to see separation as preferable to an unhappy union.[23]

[21]Bacon (n. 4 above), pp. 4–5.

[22]Alexander Silverman to John G. Bowman, October 11, 1935, Pitt, FF 80; A. W. and R. B. Mellon to John G. Bowman, June 27, 1921, Mellon Trust Papers, "Mellon Institute of Industrial Research" file; and University of Pittsburgh, *Report of the Chancellor, January 1, 1921 to June 30, 1922*, p. 10. *Happy All Day Through* was a book of verse for children.

[23]The Mellons first signaled their intention to redraft their agreement with the University of Pittsburgh in 1927. See A. W. and R. B. Mellon to E. R. Weidlein, May 29, 1927, in Minutes of Trustee Meetings, Mellon Institute, Carnegie Mellon University Archives (hereafter cited as MI Minutes, CMU). By the terms of the 1928 settlement some cooperation would continue: lectures at the Mellon Institute would be open to members of the university community, Mellon fellows would have free access to university courses, and John G. Bowman would hold a position on the five-member board of trustees of the Mellon Institute. Although there would be overlap between the boards of trustees of the two institutions (the Mellon brothers also served on both, as did Edward Weidlein), the agreement stipulated that each of the parties would "exercise its functions as a separate and distinct institution." See "Articles of Agreement," February 27, 1928, Pitt, FF 44.

Trends begun under Bacon were sustained during the 1920s and 1930s under his successor, Edward Ray Weidlein. Weidlein's scientific credentials were modest: a master's degree in chemistry and a few scattered contributions to the journal literature. But Weidlein had earned Duncan's admiration, at first by dint of a flamboyant loyalty that led Weidlein literally into the bellies of whales, and later by virtue of his competence at satisfying sponsors.[24] The son of a cattle rancher and oilman, Weidlein traveled more easily among executives than among scientists. "Industry is preferable to genius," he wrote shortly after becoming director of the Mellon Institute: "It may never carry any one man as far as genius has advanced individuals, but patient study and intelligent industry will carry thousands into comfort, and even into celebrity, with certainty; whereas genius often refuses to be managed." To advance his vision, industrial fellows were given instruction in business correspondence, technical reporting, professional ethics, and

> most important of all, in the psychology of the industrial mind. The relative prominence accorded to this subject makes it gradually easy for a young scientist of correct attitude to appreciate the industrial point of view. It teaches him to convey to the industrial executive the ideas of science and the results of research in a manner and language that can be easily comprehended. In industrial research, particularly in the practical connections with the companies sustaining their Fellowship work, the art of making and keeping contact and of promoting cordial relations is of constant utility to the Fellows.[25]

Like Andrew Mellon, Weidlein placed little stock in science or scientists unless they could prove their utility in the world of commerce and manufacture.

With or without genius, Weidlein led the Mellon Institute into its glory years. The value of contracts grew steadily during the 1920s, as did the size of the institute's staff. In 1919–20, $300,000 of sponsored research supported the work of eighty-three fellows; by 1928–29, the institute

[24]Weidlein's first project as an industrial fellow at Kansas entailed a trip to Newfoundland and Labrador where he carved the suprarenal glands from whales in hopes of using them as a source of epinephrine. See E. O. Rhodes, "Edward Ray Weidlein at Kansas," February 15, 1940, CMU. Weidlein also developed some expertise in camphor production and the recovery of copper from low-grade ores while working for Duncan at Kansas.

[25]Edward R. Weidlein, "The Administration of Industrial Research," *Industrial and Engineering Chemistry* 18 (1926) (reprint), p. 5.

housed 145 fellows and had an income of $800,000.[26] Firms in which the Mellons held significant interests, notably Gulf Oil, sponsored some of the largest projects, but most of the institute's business came from other sources. A few fellowships produced home runs for sponsors: George Curme, perhaps the scientist at Mellon with the best claim to brilliance, made critical contributions to the use of natural gas and petroleum as feedstocks for fine chemicals hitherto made from coal tar. His work, sponsored by Union Carbide, led to new synthetic routes for the production of glycols, ethers, ethanolamines, alcohols, and acetates. Products such as ethylene glycol antifreeze, patented at the Mellon Institute, made Union Carbide a major manufacturer of chemicals.[27] More often the results were singles: new materials for dental filling and building construction, improvements in the design of kilns and in the composition of the bricks used in blast furnaces, and research directed toward finding uses for the by-products of coke production. The institute's research ran the gamut from soup to nuts. It worked on the development of new soups for the Heinz Company, including one made from petroleum, and developed methods for keeping nuts dry in store displays for the Kaufmann department stores. As these examples suggest, the institute found a niche as a provider of problem-solving services. Avoiding both the routine analytical chores that were the staple of commercial testing laboratories and the discipline-directed research characteristic of universities, it instead specialized in providing solutions for well-defined problems of limited scope, whether these entailed the removal of bottlenecks in production, product improvement, or the search for new uses of materials.

With a long list of sponsors eager to fund fellowships and no room for expansion, the Mellon brothers in 1928 granted Weidlein authority to commission the construction of a new building for their institute. This would be no ordinary laboratory, but a palace of limestone and granite surrounded by 62 ionic columns, each weighing more than 60 tons (fig. 1). Located on Fifth Avenue in the Oakland section of Pittsburgh, the new building would be a short stroll from the old Mellon Institute, the University of Pittsburgh, and the Carnegie Institute of Technology (fig. 2). The building would be the length of a football field and almost as broad as it was long; inside there would be eight floors of laboratories, a wood-paneled library, dining facilities, and space for the construction

[26]Raymond F. Bacon, "The Mellon Institute of Industrial Research," in University of Pittsburgh, *Report of the Chancellor, Year Ending June 30, 1920*, p. 85; Edward R. Weidlein, "Annual Report of the Industrial Fellowships of Mellon Institute," in "Reports to Chancellor from Deans and Other Officers, 1928–1929," Pitt.

[27]Peter H. Spitz, *Petrochemicals: The Rise of an Industry* (New York, 1988), pp. 70–81.

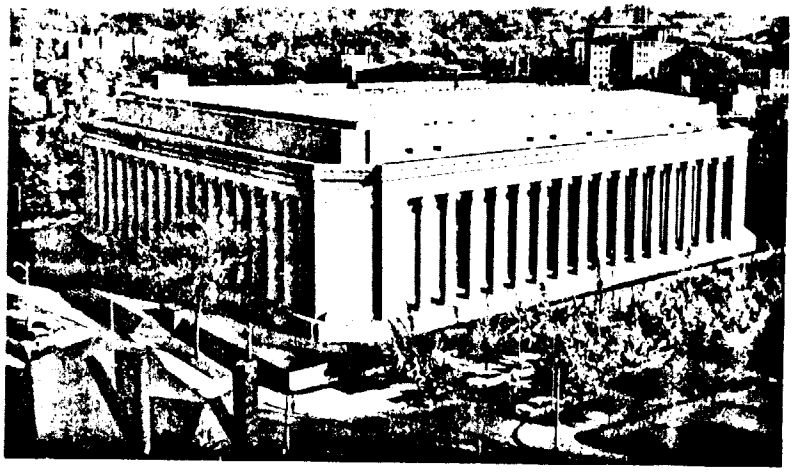

FIG. 1.—The Mellon Institute, ca. 1960. (Courtesy of Carnegie Mellon University Archives.)

of demonstration-scale industrial equipment. As a boost for Alcoa, in which the Mellons held a substantial interest, window frames and doors would be made of aluminum. Plans for game and billiard rooms were canceled as "economy measures" during construction, and some interior space was left uncompleted—by 1934, it appears, even the Mellons were feeling the Depression's pinch. Nevertheless, when dedicated in 1937, the new Mellon Institute was among the largest and most expensive research laboratories ever built in the United States.[28]

Weidlein's annual reports during the subsequent two decades tell a tale of uninterrupted expansion and prosperity: new contracts, steady growth in staff, income, and expenditures, and monotonously regular

[28]Edward R. Weidlein, "The Activities of the Mellon Institute during 1930–1931," *Industrial and Engineering Chemistry News Edition* 9 (1931): 107; MI Minutes, CMU, December 18, 1934, and January 29, 1935. Despite anxiety among the trustees, the Depression did not make this monumental structure obsolete before its occupancy. A year after entering the new building, Weidlein was able to report that finished spaces within the structure were filled almost to capacity; by 1940 the trustees felt sufficiently secure about business prospects to authorize the installation of laboratory equipment in unfinished spaces. MI Minutes, CMU, April 5, 1938, and February 6, 1940.

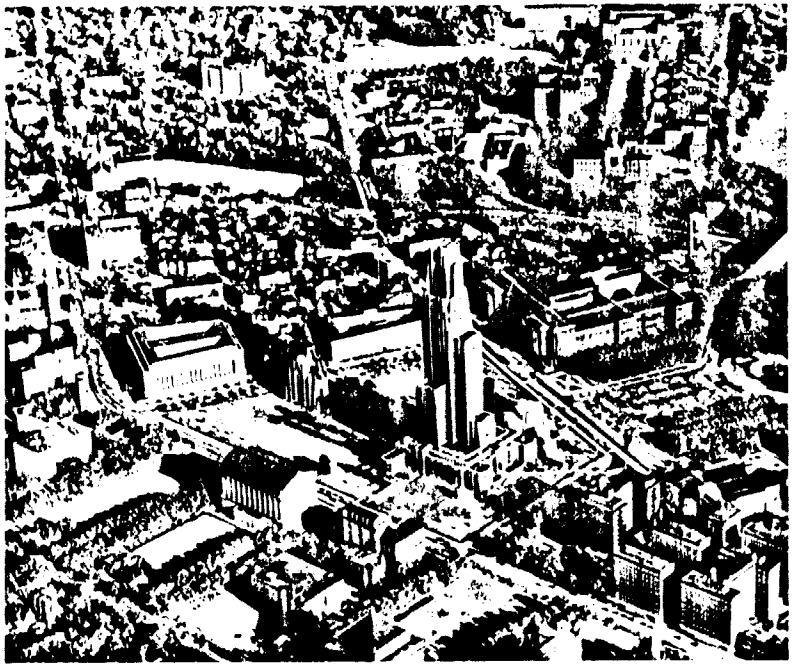

FIG. 2.—The Mellon Institute (left), located near the University of Pittsburgh (center) and the Carnegie Institute of Technology (upper right). (Courtesy of Carnegie Mellon University Archives.)

announcements of advances in industrial technology. Yet despite the optimism and successes, all was not well. As if in obedience to the German adage warning that, when the house is finished, it is time to die, Andrew Mellon's death followed the dedication of the new building by weeks. His institute, although generously endowed by his estate, felt the loss of his strong will and simple vision—more, perhaps, than its managers realized. During his lifetime, Andrew Mellon had used his enormous wealth and power to mold the Mellon Institute into a formidable agency of applied research. Like Duncan, he was suspicious of academics who advocated the study of science for the sake of science. Pure research was a luxury for a handful of professors at universities; the Mellon Institute would be dedicated not to the enlargement of human understanding but to the creation and improvement of industrial technologies. Knowledge of fundamental principles might be generated as a by-product of such labor, but it would be created by practical men (and a few women) seeking to meet practical needs. Weidlein shared

this view of the Mellon Institute, as did most of the institute's other administrators and trustees.[29]

Andrew Mellon's successors did not have such a single-minded vision. Between 1937 and 1951 the institute was managed by Weidlein and banking associates of Andrew Mellon. Members of the Mellon family sat on the board of trustees but seldom took active part in the institute's affairs. Deaths among the older generation of trustees, however, stimulated members of the family to assume a greater role in the early 1950s. Leadership fell to Andrew Mellon's only son, Paul. A graduate of Yale and Oxford whose tastes ran to classical languages and poetry, Paul Mellon showed a respect for "expert" opinion and an ambition for academic recognition absent in his father's makeup.[30] In 1951, as the time approached for Weidlein to retire, the board of trustees took a step that the secretive Andrew Mellon might well have considered foolish: they called in a panel of outsiders to review the institute's operations and to make recommendations about its future direction and management. The committee charged with this delicate task was headed not by a businessman, but rather by the physicist who ran the Massachusetts Institute of Technology, Karl Compton.[31]

The Compton committee's report offered a dramatic contrast to Weidlein's pastel portrait of the Mellon Institute. Whereas few corporations had possessed their own research facilities at the time of the Mellon Institute's foundation, now American firms had 3,400 research laboratories. Whereas chemistry had been the premier industrial science, physics and electronics now seemed to offer greater prospects for growth. Sponsors, the panel suggested, were growing restive with an administration that had lost touch both with their technical needs and

[29]A small program in "pure research" was begun in 1927 and financed primarily through annual $25,000 gifts from the Mellon family. The decision to establish this program was made when the institute became autonomous from the University of Pittsburgh, a coincidence that later led one official at the Mellon Educational and Charitable Trust to wonder whether the creation of this small program may have been designed to help the institute protect its tax-exempt status. See A. W. and R. B. Mellon to E. R. Weidlein, May 29, 1927, MI Minutes, CMU, and P. S. Broughton to A. W. Schmidt, October 23, 1956, Mellon Trust Papers, "Mellon Institute of Industrial Research" file.

[30]O'Connor (n. 3 above), pp. 359–61; Paul Mellon, *Reflections in a Silver Spoon: A Memoir* (New York, 1992).

[31]MI Minutes, CMU, July 17, 1951. The minutes make a point of noting that E. R. Weidlein was author of the motion that authorized the review, although readers must wonder how enthusiastic he could have been to have his stewardship audited by a panel led by an academic. Other members of the Compton committee included the University of Illinois's eminent organic chemist, Roger Adams; H. B. McClure; E. W. Reid, a chemist and executive of the Union Carbide Corporation; and C. G. Suits, a physicist and executive at General Electric.

the science that could meet those needs. Unmentioned in the report, although surely on the minds of its authors, was the growing competition the Mellon Institute was facing from other nonprofit vendors of research. Where once the institute had enjoyed a near monopoly on contract research for industry, there was now competition from the Battelle Memorial Institute, the Armour Research Foundation, the Midwest Research Institute of Kansas City, and the Stanford Research Institute. Several of these new institutes were tapping federal research funds, a resource that the Mellon Institute had neglected except during the war years.

Predictably, Compton's panel recommended significant changes in policy and management: appointment of a new director with strong scientific credentials; creation of a scientific advisory board to set research policy; establishment of closer relations with the University of Pittsburgh and Carnegie Institute of Technology; recruitment of more Ph.D.s to diversify the institute's resources and to improve what seemed to the panel a low ratio of Ph.D.s to support personnel; and enlargement of the institute's program in basic research both to enhance services available to sponsors and to attract bright young scientists to the institute. Quoting one unnamed consultant, the panel suggested that the institute's "research men are too nicely protected to compete with industry and lack the intellectual stimulation to compete with the universities. The Mellon Institute must emphasize one or the other."[32] The panel left little doubt about where it believed the accent should be placed.

The trustees of the Mellon Institute took no immediate action on these recommendations. Surviving records do not make clear whether they were paralyzed by a split within their ranks or were acting deliberately to cushion the feelings of those members of the board who were closely associated with the policies of the past. When Weidlein retired, however, the trustees wasted little time in bringing in a new management. At the urging of Richard King Mellon, Richard B. Mellon's son, the trustees appointed General Matthew B. Ridgway to be Weidlein's successor as chief executive officer.[33] Ridgway lacked scientific credentials and business experience, but he had dignity in abundance and contacts in Washington. Joining him in the newly created role of scientific director was Paul J. Flory, a forty-six-year-old professor of chemistry from Cornell whose work on the theory of polymerization

[32]K. T. Compton et al., "Panel Report to the Trustees of the Mellon Institute of Industrial Research," April 30, 1953, Mellon Trust Papers, "Mellon Institute, Fundamental Research" file.

[33]Paul Mellon (n. 30 above), p. 351. Richard King Mellon, a military buff and National Guard general, had a long-standing friendship with Ridgway.

reactions would later earn him a Nobel Prize.[34] Recognizing that Ridgway was unprepared to set scientific policy, the trustees had divided Weidlein's job into two parts, one dealing with sales, budgets, and personnel and the other with research supervision.

Flory was precisely the kind of director the Compton committee had envisioned: young, energetic, and committed to the values of the university. He arrived at the Mellon Institute preaching the message of Vannevar Bush's *Science, the Endless Frontier:* fundamental research undergirds advances in applied science and technology. The Mellon Institute, like the United States as a whole, had paid too much attention to practical results, with "learning 'how' to achieve a practical objective," and too little to the "why" of natural phenomena.[35] The nation could no longer, as in years past, rely on Europe for new ideas. Nor could it expect its research institutions to respond spontaneously to the new needs. Experience shows, Flory argued, that in institutions attempting to foster both types of work researchers tend to turn to applied problems in preference to basic research. "The objective of the applied project," he wrote, "is easily explicable, readily justified, and gives promise of tangible results within a reasonable period. The investigator pursuing a fundamental approach may have difficulty justifying his course of action and, though the research may be important, he has only a glimmer of hope that the results will be of practical value to his employer. . . . Small wonder that his initial idealism soon yields to the appeal of the better assured future enjoyed by his fellows in applied research."[36]

The poisonous effects of applied research on basic science, Flory suggested, helped explain why universities had long dominated work in fundamentals while industrial research laboratories had come to enjoy supremacy in studies of the applications of science. Nor did he see much change in this division of labor in the future. The industrial research laboratory, Flory asserted, would remain the natural site for applied research since it enjoyed the advantages of close liaison with development, production, and sales departments. Universities were, and would

[34]Flory also had some industrial experience. He began his career as an assistant to Wallace H. Carothers at Du Pont's "Purity Hall." Of all research groups supported by American industry, Carothers's probably had the strongest commitment to the pursuit of scientific rather than commercial results; it is likely that Flory's views were shaped as much by this apprenticeship as by his academic experience. On Carothers, see David A. Hounshell and John Kenly Smith, Jr., *Science and Corporate Strategy: Du Pont R&D, 1902–1980* (New York, 1988), pp. 223–48.

[35]P. J. Flory, "A Proposal Respecting the Future of Scientific Research in Mellon Institute," August 24, 1956, Mellon Trust Papers, "Mellon Institute, Fundamental Research" file.

[36]Ibid.

continue to be, natural centers of basic research since they offered scientists refuge from the pressures of the marketplace.

The division of labor that Flory saw as a logical consequence of the properties of basic and applied research posed a dilemma for the Mellon Institute. Neither an industrial research laboratory nor a university, it was a mixed body—a place caught between the worlds of basic and applied science. Over the long term, his analysis suggested, it could not continue to compete for industrial investment with in-house laboratories since the latter enjoyed more intimate relations with sponsors' managers, salesmen, and engineers. Nor, so long as its staff was constantly distracted by the market-oriented projects of industrial sponsors, could it enter the charmed circle of research universities and compete for the federal funds now being lavished on basic science. The solution, in Flory's view, was to steer the Mellon Institute toward the academic model—to make the institute over into a research university without classrooms. In Germany and the Soviet Union, Flory noted, institutes for basic research often existed apart from universities. By aspiring to become such, the Mellon Institute could win access to abundant federal dollars, avoid the costs and burdens of teaching, and sell its services to enlightened firms that appreciated the value of long-term fundamental research. "Always, however, the effort should be concentrated on advanced scientific research and exploration in new areas of science."[37]

Access to federal funds was crucial to Flory's plan. Federal grants were typically larger than industrial fellowships, their administrative costs were lower, and they offered greater opportunities to engage in basic research—or so it seemed. Flory was confident that the Mellon Institute, once freed of its grimy industrial fellowships and rebuilt as a center for basic research, would get its share of federal grants: "Rare indeed are instances of a good research proposal from a university which does not find support from the National Science Foundation, AEC, or one of the various military agencies. Sponsorship of second or third rate projects occurs frequently (as is perhaps inevitable), and the overcommitted professor is commonplace."[38] It was easy for Flory, in 1956, to believe that federal largesse had created a golden opportunity for the Mellon Institute and its scientists. Washington's expenditures on research and development would double as a percentage of gross national product between 1953 and 1958, and outlays for basic research, although modest by comparison with spending on applications, were growing faster than appropriations for applied research and development.[39]

[37]Ibid.

[38]Ibid.

[39]David C. Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth* (New York, 1989), tables 6.2 and 6.4.

Flory recognized that a change in the institute's course would demand expert piloting and generous support from the trustees. Fellowships with immediate or practical aims—that is to say, the majority of Mellon's contracts—would have to be revised or abandoned. Personnel with narrow or purely practical expertise would have to be eased out of their fellowships. New departments would have to be organized around the study of fundamental problems in catalysis and surface chemistry, sold-state physics, and polymer science. The institute would have to recruit aggressively at major research universities. To attract promising young scientists, pay and benefits would have to be improved and provisions would have to be made for job security comparable to that enjoyed by tenured faculty—something that industrial fellows had never enjoyed. The institute would need exchange programs with universities, a sabbatical program, and positions for postdoctoral students to promote a properly academic atmosphere. And, of course, scientists in the new Mellon Institute would need freedom. Contributions to the scientific literature, Flory insisted, ought to be the central determinant in promotion and the institute would have to abandon those policies that obstructed publication. "Above all," Flory wrote, "*programs of research must be generated internally,* either by the investigators themselves or in collaboration with their superiors on the staff. Specific objectives should not be dictated by external sponsors."[40] As at universities, proposals from outside parties should be accepted only if they conformed to the institute's aim of advancing science and fitted with the interests of the research workers concerned. Over time, Flory predicted, new income from the federal government and enlightened corporations would more than compensate for lost business and increased operating expenses. With more optimism than reason, he suggested that the transition might be accomplished in four or five years.

While Flory was embarking on his scheme to reconstitute the institute's policies, personnel, and culture, Ridgway and the trustees launched an equally ambitious program to develop a new "campus" for the institute. A tract of land was purchased in Bushy Run, 23 miles east of Pittsburgh. In October 1956, only weeks after Flory was appointed scientific director, Ridgway announced that the institute would construct a Radiation Laboratory on this land. The centerpiece of the laboratory would be a 3-million-volt Van de Graaff accelerator; its goal would be to explore the industrial uses of radiation and to make the Mellon Institute more competitive in bids for Atomic Energy Commission contracts.[41]

[40]Flory (n. 35 above).

[41]*Pittsburgh Sun Telegraph,* October 23, 1956.

The wherewithal to finance this simultaneous reorganization and expansion was to come from the same fortune that had created the Mellon Institute. After the deaths of Richard B. and Andrew W. Mellon in the 1930s, the bulk of their fortune was left to three foundations controlled by their children: the Andrew W. and Richard B. Mellon Charitable and Educational Trust, the Sarah Mellon Scaife Foundation, and the Richard King Mellon Foundation. Although seeking to define new philanthropic roles for the Mellon fortune, the managers of these foundations felt a strong responsibility to sustain those nonprofit projects that had been important to the founders. At the same time, however, some had strong doubts about the viability of a Mellon Institute dedicated to internally generated research. "Even if industry now will support basic research, what evidence is there that industry would rather support basic research in a separate institute than within the orbit of a university?" asked one official. "Modern trends in industry," he added, "run the other way." Of course, contributions could be had from industries in which the Mellon family has a strong voice, but such support "would presage eventual failure. The institutional concept has to be sound." If, as seemed more likely, the new Mellon Institute would not be able to support itself through contract research, then what would be the magnitude of the eventual need? Even the Mellon fortune might not be able to meet the appetite of a large and ambitious research institution.[42]

Despite reservations, the trustees of the three foundations, under strong pressure from the family, voted in December 1956 to appropriate $2 million to cover the expenses of building a radiation laboratory at Bushy Run and an additional $18 million to endow basic research at the Mellon Institute. Income from the newly enlarged endowment, it was hoped, would be adequate to cover the expenses of Flory's reforms and to keep the institute solvent during its transition to a program of basic research. It might also be used to close budget deficits if industry and government threw less business to the new Mellon Institute than Flory and Ridgway projected.

Ridgway and Flory worked vigorously to make their gamble pay, but despite those efforts disappointments proved far more common than successes. Flory's plans for building up strong teams of young research scientists foundered because of the extremely tight market for top-notch scientists in the late 1950s. Ironically, while Flory had lamented Americans' indifference to fundamental research, the country had already entered an era of unprecedented hunger for basic science and its practitioners. The intense demand for skillful and creative scientists was

[42]P. S. Broughton to A. W. Schmidt, October 23, 1956, Mellon Trust Papers, "Mellon Institute of Industrial Research" file.

fueled principally by large federal grants and expenditures but also by the decisions of some large and diversified corporations to redirect resources to basic science in the aftermath of the world war.[43] Flory had some sense of the direction in which resources were moving; his plans for the Mellon Institute were predicated on a belief that government and industry would soon be seeking new facilities for fundamental research. What Flory and his colleagues did not appreciate was the magnitude and pace of the shift. The rush to secure talented scientists, especially those capable of stimulating and guiding groups of researchers, made recruiting difficult at best. The Mellon Institute, with its reputation for work on mundane industrial problems, red tape, and secrecy, could hardly compete on equal terms with research universities or even want-to-be research universities.

Scientists were skeptical about prospects for change at Mellon, but the managers of industrial research who had been the institute's traditional clients proved all-too-quick to appreciate the position of applied research in the new regime: their fellowship funds and overhead payments would help pay the institute's bills while it was being remade into a kind of Institute for Advanced Study. Some long-time clients wondered if they were simply being treated as cash cows, capable of producing milk but not worth much attention or respect. It is not surprising that a wave of contract terminations began shortly after plans for making the Mellon into a center of basic research were announced. Flory and Ridgway had expected and, indeed, hoped that some industrial contracts would be ended, but they had not anticipated the speed and volume of the response. Nor had they anticipated the difficulties Mellon would have in replacing lost contracts with new business. Private industry proved very reluctant to fund basic research through fellowship grants, preferring to invest money in its own laboratories or simply to make grants to universities. Government support proved less generous and less attractive than Flory and his associates had imagined it would be: "Although our relations with the Government are generally excellent, on occasion we have experienced surprising or unfortunate reactions. Agencies have rejected as many of our proposals as they have accepted. Proposals of unusual merit have been rejected. In at least one instance, support was contingent upon exploration along lines espoused by the agency office (but soon abandoned there)."[44]

[43]Hounshell and Smith (n. 34 above), pp. 352–55, 360–61, 366–67. For an excellent survey of national trends in research and development spending during this period, see Mowery and Rosenberg, pp. 123–68.

[44]A. A. Bothner-By, T. G. Fox, T. H. Davies, and H. P. Klug, "A Progress Report on Research at Mellon Institute," undated memo written in 1961, "Mellon Institute—History and Information 1961" folder, "Projected Thoughts of Future of Mellon Institute" box, Mellon Institute Papers, CMU.

The conclusion the directors of research at Mellon drew from this experience was that it would be best to confine government contracts to a maximum of 40 percent of the "independent" research at the institute. Indeed, "the independence we require in the choice of our researches may be compromised" if external support, from all sources, exceeded the 50 percent level.[45] So ended Flory's hope that the institute's basic research might someday become self-sustaining.

As the volume of research business fell off and red ink began to spread over the institute's balance sheets, the trustees increased overhead charges from 25 percent of a sponsor's direct costs to 37.5 percent. The hike stimulated another round of cancellations.[46] By 1960, projections of income and expenses indicated that the institute would be running a $1 million annual deficit by 1962, and even some of the scientists Flory had hired to lead the drive toward "fundamental research" were beginning to rue his emphasis on the term. "It now seems," wrote four of his staff fellows, "that the exclusive use of the term 'fundamental research,' to distinguish our independent research from the earlier applied Fellowships was unfortunate. This, in addition to possibly inadequate explanation of our objectives and methods to industry in general, and particularly to certain of those long associated with the Mellon Institute, may have added up to poor public relations in some quarters."[47]

Rather than acknowledge failure, the board of trustees tinkered with the institute's personnel and organization. In 1960, Paul Mellon persuaded Ridgway to take early retirement and tried his own hand at management.[48] The classicist was no better qualified to run a research institute than the distinguished general. Months after Mellon took office, Flory tendered his resignation to take a position at Stanford. Flory's ideas, forceful expression, clear speech and prose, prestige, and vision had been critical in launching the institute on its new path. His loss left the institute without a pilot. Morale within the organization plummeted as rumors circulated about a return to an earlier model of management.[49] Recognizing that he could not hope to fill Flory's shoes, Mellon placed management in the hands of another academic chemist, Paul Cross of the University of Washington. New seats were created on the board so as to bring such leading scientists and managers of science as William O. Baker of Bell Laboratories, James R. Killian of MIT, and Lee A. DuBridge of the California Institute of Technology into its

[45]Ibid.

[46]MI Minutes, CMU, March 19, 1957, and May 7, 1957.

[47]Bothner-By, Fox, Davies, and Klug.

[48]MI Minutes, CMU, May 12, 1960; *Pittsburgh Press*, May 15, 1960; Paul Mellon (n. 30 above), p. 351.

[49]Mellon Institute of Industrial Research, Pitt, Periodic Report no. 21, May 4, 1961, p. 2.

counsels. On DuBridge's suggestion, an Industrial Affiliates program was created that bore some similarity to the Associates program Caltech had long used to raise funds. Just as the Caltech Associates program gave wealthy contributors access to lectures and social events in exchange for pledges of $10,000, so the Industrial Affiliates program at Mellon would give corporations access to seminars and the results of the institute's fundamental researches in return for payments of $25,000 per year.[50] But since the institute's scientists were now being encouraged to share their work through normal channels of scientific communication, very few corporations saw much advantage in paying for what could be had for free. Nor did the Mellon Institute enjoy the advantages of universities in such fund-raising—principally, a large and loyal cadre of well-placed graduates. Astonishingly, the management of the Mellon Institute was surprised and disappointed by the poor response.[51]

By January 1, 1961, revenues from sponsored applied research had fallen to $3.53 million, about a million less than in the last years of Weidlein's administration. Grants and contracts for fundamental, or, as it now was usually called, "independent," research had grown to a level of $0.87 million, but total operating income was actually less than it had been five years earlier, even excluding the effects of inflation.[52] Nor did this uninspired financial performance improve during the next few years. As of April 30, 1965, revenues from sponsored applied research had declined again, now to an annual level of $3.28 million.[53] Income from grants and contracts for fundamental research had increased to $1.38 million, almost entirely as the result of aggressive efforts to land federal grants, but the growth in this sector was not enough to bring the institute's total income from external sources back to the level of 1955.[54] The Mellon Institute had managed to pass through a decade of unprecedented prosperity in the nation's research and development sector without growing at all.

[50]Bothner-By, Fox, Davies, and Klug. Participants in the Affiliates program agreed to allow the institute to use the funds as it saw fit. In return, the institute agreed to keep the affiliate informed of the progress of the research being subsidized and to discuss its work with personnel from the sponsoring firm who had "appropriate background." In addition, the affiliate could place qualified employees in institute laboratories so long as the affiliate paid the salary of the visitor and all expenses entailed in his research at the institute. The authors of this report rightly noted that the value accruing to the affiliate appeared "somewhat intangible and is not immediately obvious."

[51]MI Minutes, CMU, November 20, 1963.

[52]Mellon Institute of Industrial Research, Periodic Report no. 20, January 5, 1961, Pitt, pp. 6, 9.

[53]Mellon Institute of Industrial Research, Periodic Report no. 35, August 31, 1965, Pitt, pp. 1, 14.

[54]Ibid., p. 1; MI Minutes, CMU, May 19, 1966.

More alarming than the indifferent record of the previous ten years were the prospects for the future. When dealing with the government, the institute had to spend money in order to make money; in most cases, far more had to be spent than could be recovered. To position itself to win government grants, the institute had to recruit in advance of filing proposals since granting agencies typically expected the institute to have in place the personnel necessary to prosecute research.[55] Industrial fellows, by contrast, could be hired after business firms placed orders for work. Nor could the institute readily discard scientists hired to conduct fundamental research after their grants expired. Investigators capable of attracting large federal grants would consider employment at the Mellon Institute only if offered assurances regarding future employment and benefits. The institute generally did not have to make such commitments to industrial fellows; when fellowships expired the sponsor usually hired fellows or assisted them in finding work within the industry, and many industrial sponsors offered fellows insurance and retirement benefits through their own corporate plans. The institute's shift from a strategy of relying on industrial contracts to finance applied research to a strategy of using government funds to support fundamental research had led to an erosion in external support and an increase in fixed costs. For the ordinary business firm, this would have been a formula for bankruptcy.

The Mellon Institute, of course, was not an ordinary business firm. It enjoyed the good will of the Mellon family. Between September 1956 and January 1962, trusts and foundations controlled by the children of A. W. and R. B. Mellon contributed over $30 million to the Mellon Institute. Most of these millions flowed into an endowment fund that generated the income necessary to pay for the institute's expansion into basic research. Flory and Ridgway had hoped that income from endowment would nurture the institute's fundamental research program until it could stand on its own; yet in 1965, over half of the institute's expenditures on fundamental research were still being underwritten by income from endowment. What had been envisioned as seed money was coming to look like a permanent dole.

During the heady days of John Kennedy's New Frontier, the trustees and management of the Mellon Institute could preserve some hope that ever-increasing federal expenditures on science and widespread business rhetoric about the value of basic research would eventually lead to greater revenues. By the mid-1960s, however, prospects were looking dimmer and dimmer. Private industry, disillusioned with basic science, was becoming more and more reluctant to sink money into open-ended

[55]Mellon Institute of Industrial Research, Periodic Report no. 21 (n. 49 above), p. 17.

research projects.[56] Meanwhile, increases in federal spending on research were far smaller than they had been in the aftermath of *Sputnik*, and the government had begun to shift funds from grants for basic research toward mission-oriented projects. Many of these carried restrictions that were obnoxious to the scientists who had recently come to the Mellon Institute to work on topics of their own choosing. As unrestricted federal grants became harder to secure, the administrators of the agencies awarding those grants became pickier and tended to prefer academic applicants to those coming from institutions like the Mellon. The National Science Foundation (NSF), lamented one department head at the Mellon Institute, "considers as its main responsibility the use of its funds to support the training of new scientists. Presumably in the NSF offices there may be, openly expressed or not, a body of opinion that regards us (1) as a consumer of scientists rather than a supplier and (2) as a center of low grade profit motivated industrial technology. Then, they may feel that money invested here tends to defeat rather than contribute to their own central objective."[57]

Perhaps the straw that broke the camel's back was the failure of the institute to secure a major contract as a materials science center from the Defense Advanced Research Projects Agency (DARPA) in 1965. The institute's management had invested much hope and no little effort in trying to persuade officials at DARPA that the Mellon Institute was a logical site for advanced research and development work on new materials. As they saw it, not only could Pittsburgh boast of dozens of companies specializing in the production and fabrication of metals, ceramics, and plastics, the Mellon Institute also had unique qualifications as a site: a staff with strong credentials in polymer science, superb facilities, and a long history of successful work on the development and application of new materials. Had Mellon been able to secure this contract, it would have gained a stable and long-term supply of government funds that could be directed to the basic and "pioneering applied research" that the Mellon's trustees and scientists most desired. The contract, it was hoped, would also bring the institute new, and more interesting, contracts with private sponsors. The agency, while acknowledging Mellon's strong credentials, expressed serious reservations about funding work at a laboratory that had organic connections neither with an educational institution, where government spending would have second-order effects through students, nor with industrial firms, where

[56]Hounshell and Smith (n. 34 above), pp. 583, 597–98.

[57]T. G Fox, Memo to Paul Cross on "Dr. Waterman's Concept of the Role of the Mellon Institute in the National Picture," December 13, 1961, "Mellon Institute—History and Information 1961" folder, "Projected Thoughts of Future of Mellon Institute" box, Mellon Institute Papers, CMU.

there were engineers and managers experienced in translating ideas into marketable products and processes.[58] The message seemed clear: the Mellon Institute was not competitive because it was neither a university nor a corporate research laboratory; to land such major contracts it would have to become one or the other.

A year after the announcement of DARPA's decision, Paul Mellon authorized a subcommittee of the institute's board of trustees to open discussions of a merger with representatives of the Carnegie Institute.[59] The president of the Carnegie Institute, H. Guyford Stever, harbored few doubts about the wisdom of a merger. An affable man in his midforties, Stever had come to Carnegie Tech in 1964 after making a reputation for himself as an aeronautical engineer and administrator at MIT. His predecessors had patiently acquired new parcels of land, built up several strong departments, and cultivated the good will of the wealthy families that dominated Pittsburgh's economy and social life. Stever, it was hoped, would marshal these resources to make Carnegie Tech into an institution of national standing—the Pittsburgh version of MIT, where Stever had taught, or of Caltech, where he had studied.

When Paul Mellon proposed a merger of Carnegie Tech and the Mellon Institute, Stever saw an opportunity for Carnegie Tech to enter the big leagues by a single leap. Carnegie Tech needed land for expansion, money for research, and the staff and facilities capable of attracting graduate students in science and engineering. The Mellon Institute seemed to offer all of this. The institute's main building boasted 400,000 square feet of space and was located near the Carnegie campus. In addition, the institute owned properties adjacent to the main building and a 250-acre tract in Bushy Run. The one- and two-person laboratories in the institute's main building were well designed and offered room for hundreds of scientists and graduate

[58]MI Minutes, CMU, October 14, 1964; T. G Fox to MPC Corp., March 29, 1965, "MPC" folder, President's Papers, CMU.

[59]MI Minutes, CMU, May 19, 1965, and September 13, 1966. Paul Mellon had discussed the possibility of a merger with Carnegie Tech at the time of Paul Flory's resignation. The idea was scuttled, however, when the chancellor of the University of Pittsburgh, Edward H. Litchfield, learned of the negotiations and protested that a combination of the Mellon and Carnegie institutes would undermine his efforts to build a research university with first-class programs in science and engineering. Litchfield at that time enjoyed the strong support of the Scaife branch of the Mellon clan; by 1966, Litchfield had forfeited that support through mismanagement and clumsy political maneuvering. On the earlier merger discussions, see MI Minutes, CMU, January 17, 1961, and Ludwig Schaefer interview with John C. Warner, CMU. Perhaps in order to avoid such unwanted pressures from third parties, the 1966 negotiations were conducted in secret; some members of the Mellon Institute's board of trustees did not learn of them until after the terms of an agreement had been worked out.

students. Representatives of Carnegie Tech who toured the facilities marveled at the fine appointments, the abundance of "valuable and useful equipment," and the "excellent shop facilities."[60]

Not least appealing to Stever and his lieutenants was the prospect of gaining access to the Mellon Institute's endowment. By absorbing the institute's free cash and investments, worth about $37 million, Carnegie Tech would overnight increase the market value of its endowment by 50 percent.[61] No one needed to tell Stever that if a merger cemented good relations with the Mellon clan Carnegie Tech might reap additional millions in future years. Presidents of Carnegie Tech had long been seeking to wean the Mellons away from their traditional attachment to the University of Pittsburgh; relieving the family of an unwanted burden and appending the Mellon name to the title of the new conglomerate might quickly achieve what years of patient courting had not. Nor would a merger simply open the door to new private resources; it would also, Stever hoped, give the postmerger university a better claim on large federal grants than either institution had on its own. The outcome of a merger, Stever asserted, would not only be a larger and stronger Carnegie Tech but also a new university that would "give additional impetus to Pittsburgh's position in science and contribute more to the development of science and science-related activities in the community and nation."[62] A Carnegie-Mellon combine would give Pittsburgh a focal point for scientific and technical developments similar to that which the MIT-Harvard complex gave Boston.

Stever and his associates at Carnegie Tech were so dazzled by the Mellon Institute's dowry that they gave only passing attention to the bride. This became clear when it came time for Stever to provide a public explanation of the merger. Unwilling to justify the combination purely in terms of its possible monetary advantages for Carnegie Tech, Stever canvassed his deans for ideas. "I've started a half a dozen times to write a statement . . . and each time I came up with either nothing or platitudes," wrote one. "Are other deans having this trouble?"[63] They were. In his annual report, Stever sought to make the very disparity between the institutions a reason for uniting. The Mellon's strengths in

[60]Robert J. Kibbee to H. Guyford Stever, September 29, 1966, "Stever, H. G.—Mellon Institute Merger" box, President's Papers, CMU.

[61]Carnegie Institute of Technology, *Report of the President* (1966); MI Minutes, CMU, May 15, 1967.

[62]"A Proposal to Establish the Mellon Institute Science Center at Carnegie Institute of Technology," undated memo written in September 1966, "General Information on Merger" folder, "CIT-MI Merger" box, President's Papers, CMU.

[63]Erwin R. Steinberg to E. R. Schatz, April 12, 1967, "Schatz, Edward R." folder, "President's Office. Stever, H. Guyford" box, President's Papers, CMU.

polymer science and chemistry would react synergistically with Carnegie Tech's expertise in metallurgy and engineering, its commitment to research would complement Carnegie Tech's strengths in undergraduate education; its ability to attract postdoctoral fellows would strengthen Carnegie Tech's growing graduate school. By joining the Mellon's staff to Tech's, the new university would instantly be able to boast of having a highly diversified school of science and one of the largest chemistry departments in the country. Undergraduate teaching loads could be drastically reduced, and the university's programs in science and engineering would become far more appealing to graduate students. "Thus," he told readers, "it became crystal clear that combining the two institutions was not only feasible, but highly desirable."[64]

In the event, however, it proved far harder to manipulate people than boxes on an organization chart. While Mellon fellows who were engaged in fundamental research shared research interests with their academic colleagues and showed interest in taking on graduate students and postdoctoral fellows, few were eager to accept responsibilities for undergraduate instruction. For many fellows the absence of teaching duties had been part of the appeal of working at the Mellon Institute. Early in the merger negotiations, Stever had promised to give tenured professorships to most senior fellows at the Mellon Institute; in what can only be called a generous settlement, Stever stipulated that the newly minted professors would have the right to determine their own classroom duties.[65]

The Stever administration does not appear to have foreseen the strains that this arrangement would place on collegial relations in the new university; nor did it pause to consider the impact that the absorption of Mellon personnel might have on the future of Carnegie Tech's chemistry department. The great majority of Mellon fellows held credentials in chemistry; as a consequence of the merger, the number of tenured professors in the university's chemistry department doubled. Under the best of conditions, it would have been difficult to enlarge the student population to justify such an expansion. In the late 1960s, it proved impossible. By 1968, the Carnegie-Mellon trustees were expressing dismay at imbalances in that department.[66] With so many tenured professors, however, little could be done to remedy the excess until attrition corrected the problem.

[64]Carnegie Mellon University, *Annual Report of the President, 1966–1967*, p. 3.

[65]John C. Warner, Stever's predecessor as president of the Carnegie Institute of Technology, offers frank criticism of Stever and the "wholesale" appointment of Mellon fellows to tenured positions in his interview with Ludwig Schaeffer (n. 59 above).

[66]Minutes of Meeting of the Mellon Institute Committee of the Board of Trustees of Carnegie Mellon University, January 11, 1968, CMU.

Even more difficult was the challenge of integrating the Mellon Institute's industrial fellows into the new Carnegie-Mellon University. At the time of the merger, industrial fellowships still supplied almost three-quarters of the Mellon Institute's outside income, and, as many faculty members at Carnegie Tech understood, those fellowships entailed work that could have little relationship to the educational or research mission of a university. Many fellows had spent years in service to industrial sponsors interested in finding solutions to such specialized problems as bonding asbestos to steel plate or improving the flavor of chicken soup. Some were many years removed from graduate school; few had experience as teachers. The trustees and management of the Mellon Institute felt some moral obligation to these scientists and their sponsors and recognized that fellowship income paid for the lavish support services that visitors from Carnegie Tech found so impressive. Stever agreed to honor all of the Mellon Institute's existing contracts and commitments, both as a concession to the Mellon family and out of the desire to preserve the cash flow from industrial sponsors. To ensure that these promises were kept, several of the Mellon Institute's trustees were added to the governing board of Carnegie Tech and placed on a special subcommittee that would monitor the implementation of the merger during a two-year transition period.[67] Neither Stever nor his associates, however, confronted the question of how industrial fellowships and their holders would fit into a university.

The result was uncertainty and confusion. Carnegie Tech had policies for dealing with contract research that contradicted those of the Mellon Institute. At Carnegie Tech, professors could work for several sponsors and engage in private consulting; at Mellon, fellows were prohibited from working for more than one sponsor at a time and private consulting was prohibited. At Carnegie Tech, faculty members typically initiated contacts with sponsors and supervised projects; at Mellon, full-time administrators located sponsors and managed projects. At Carnegie Tech, support services were limited and assistants were generally graduate students; at Mellon, support services were extensive and assistants were full-time technicians. At Carnegie Tech, the institute retained rights to patents; at Mellon, the sponsor received patent rights. At Carnegie Tech, sponsors were entitled to delay publication of the results of sponsored research for only a year; at Mellon, many contracts stipulated that fellows could publish only after securing the sponsor's permission. Had the merger occurred in placid times, these discrepancies would have caused distress and conflict; in the late 1960s, amid

[67]Memorandum of Understanding, June 30, 1967, President's Papers, CMU.

swelling concern about the growth and power of "the military-industrial-academic complex" and impersonal "megaversities," they provoked fury and recriminations. Critics of the merger lobbied for the abolition of all forms of sponsored research; holders of industrial fellowships insisted that sponsored research was a legitimate academic function that benefited not only sponsors but also the university and society more generally. After years of neglect from Mellon administrators fixated on basic science, these scientists and engineers now felt themselves unfairly labeled by ivory-tower academics as stooges of malevolent corporations.[68]

Careful consideration of the issues raised by these differences did not occur until a year after the merger was effected, when a joint committee of trustees and faculty was convened to formulate university-wide policies on sponsored research. This committee took as its central premise the idea that sponsored research belongs in a university only if it serves the educational or professional needs of members of faculty and students. Involvement in sponsored research, it noted, could be especially beneficial to engineers. Nevertheless, the committee insisted that "the University must remain in firm administrative and intellectual control of sponsored on-campus research." This meant, according to the authors, that Carnegie-Mellon University should work toward establishing uniform policies in line with those that had existed at Carnegie Tech before the merger. To ensure university control over sponsored research, the committee further recommended that a Center for Sponsored Research be created that would not only assist faculty in finding sponsors for their work but would also monitor those contracts to "insure compliance with University policies."[69]

Ironically, while debate over sponsored research intensified on campus, the nature and volume of such work was changing rapidly. Only seventeen of the forty-eight industrial firms that supported research at the Mellon Institute in 1955 continued to do so at the time of the merger. By 1968, the fellowship program had suffered a net loss of another five firms and several of the remaining dozen were on the brink of canceling their contracts. While private support was dwindling, so were contracts with the military research agencies that had constituted

[68]I. I. Bezman to Warren C. Johnson, March 11, 1968, and G. P. Brown to the Committee to Examine University Policy on Sponsored Research, May 15, 1968, apps. C-1 and C-3, "Report of the Joint Trustee-Staff Committee on University Policy for Sponsored Research," September 5, 1968, "Carnegie-Mellon University" folder, "Projected Thoughts of Future of Mellon Institute" box, President's Papers, CMU.

[69]Appendixes C-1 and C-3, "Report of the Joint Trustee-Staff Committee on University Policy for Sponsored Research."

the bulk of the Mellon Institute's government business.[70] Fellows who were engaged in industrial research blamed the administration for ignoring their needs and those of their sponsors and predicted further erosion if the university did not unequivocally endorse the value of sponsored work. "In fact, without such action," wrote one senior fellow, "President Stever's famous '2 + 2' isn't going to make it all the way to three."[71] But Stever had neither a strong interest in preserving the Mellon's fellowship system nor a desire to compound his administration's growing fiscal and morale problems by engaging in unpopular crusades.

After reflecting on the joint committee's report, Stever, in 1970, endorsed its recommendation that all sponsored research at the university be brought under the jurisdiction of a new Division of Sponsored Research. Simultaneously, he acted to sever the connection between the sponsored research division and the endowment funds derived from the Mellon Institute. By a clever sleight of hand, he created a new Mellon Institute of Science that would be a degree-granting college of science embracing Carnegie-Mellon's science departments and gave the dean of that college access to both the Mellon Institute's building and endowment funds.[72]

The effect of these changes was to dissolve one party to the 1967 merger. Some of the Mellon personnel who had been engaged in basic research were now professors in the Mellon Institute of Science, but they would share access to the old Mellon Institute's endowment income and facilities with faculty from the old Carnegie Tech. Resources that had been originally earmarked to support research were now invested in education as well. A few of the fellows who had been engaged in applied research at the old Mellon Institute were now members of the faculty of the Mellon Institute of Science or the Carnegie Institute of Engineering, Carnegie-Mellon's other major division. Other industrial fellows inhabited a kind of limbo, neither regular members of the faculty nor employees of a research institute. As old sponsors allowed their contracts for fellowship research to lapse, this group grew smaller and smaller. By 1970, only one large contract remained of those inherited from the

[70]Appendix E, "Report of the Joint Trustee-Staff Committee on University Policy for Sponsored Research."

[71]W. T. Granquist to T. H. Davies, November 21, 1968, "Merger" folder, "Misc. Documents CIT-MI Merger" box, President's Papers, CMU.

[72]H. Guyford Stever, Memo of January 31, 1970, "Mellon Institute—Proposed Reorganization of Science and Engineering" folder, "Projected Thoughts of Future of Mellon Institute" box, President's Papers, CMU; Carnegie Mellon University, *Annual Report of the President, 1969–1970*, p. 4.

Mellon Institute—a $400,000-a-year agreement to conduct toxicological research for Union Carbide. This work, governed by a twenty-year agreement and housed in its own building at Bushy Run, was so distant from the Carnegie-Mellon University campus as to be nearly invisible both to campus activists and administrators.[73]

During its nearly sixty years of operation the Mellon Institute had played a significant role in American industrial research. Fellows, in addition to publishing more than 4,700 research papers, had filed 1,600 patents and developed products as diverse as Kalgon and vinylite molding compounds. The Visking Corporation, Plaskon Company, Dow-Corning Corporation, and chemical division of Union Carbide had grown from products developed at the institute, and dozens of other firms had derived substantial profit from its work. Just as important, the institute had prepared hundreds of fellows for careers in industrial research and helped to sell the very idea of research to manufacturers.[74] By most measures, it had been a success.

Yet its effectiveness as a problem-solving agency underlines the question that its managers asked repeatedly during its decline: What went wrong? Spokesmen for academic values in the 1950s and 1960s argued that the decay of the industrial fellowship system was inevitable, a consequence of the Mellon Institute's success in spreading the gospel of industrial research. As more and more firms built their own laboratories, the institute steadily lost its client base. The explanation was repeated so often as to become an article of faith. Yet the institute's history offers ample evidence to undermine this answer. As late as December 1947, long after most major American firms had established

[73]M. B. Ridgway to Messrs. Clarke and Hughes, March 1, 1957, "Union Carbide 20-Year Agreement" folder, "Miscellaneous Documents, MI/CIT Merger" box, President's Papers, CMU; Kim Poffenberger to Editor, *Tartan*, April 18, 1978. The disintegration of the Mellon Institute and its fellowship plan did not, of course, spell the end of sponsored research at CMU. When Stever resigned in 1972 to become head of the National Science Foundation, his successor was the economist Richard M. Cyert. Cyert inherited an institution that was suffering from both morale problems and a $4.3 million annual deficit. In the 1970s and 1980s, as campus concerns about sponsored research waned and new opportunities for cooperation with industry appeared, Cyert aggressively courted new industrial partners. These efforts resulted in the proliferation of such semiautonomous research institutes as the Robotics Institute (a joint undertaking with Westinghouse), the Software Engineering Institute, the Supercomputing Center, the Carnegie Mellon Research Institute, and, most recently, the Western Pennsylvania Advanced Technology Center. Some of these organizations have been successful as vendors of consulting services to industry, but none bore a genetic relationship to the original Mellon Institute or its fellowship plan. Information on these initiatives and on Cyert's evolving attitude toward sponsored research may be found in the CMU *Annual Reports*.

[74]Appendixes C-1 and C-3, "Report of the Joint Trustee-Staff Committee on University Policy for Sponsored Research" (n. 68 above), p. 5.

in-house research facilities, more than one hundred companies were on a waiting list for institute fellowships.[75] In 1955–56, the year before Ridgway and Flory assumed control, the institute enjoyed an income of $4.65 million, almost all of it from industrial sponsors. While the institute was running a small operating deficit ($0.36 million), the imbalance was due almost entirely to the trustees' decision to support a program in basic research and to omit the costs of that program from overhead charges levied on clients.[76] Nor did the growth of in-house research cripple the operations of other vendors of research during the 1950s and 1960s. The Battelle Memorial Institute, Stanford Research Institute, and Midwest Research Institute, for example, were growing rapidly while the Mellon's business languished.[77]

Fatal to the "victim of its own success" thesis, however, is the fact that the Mellon Institute had long relied on the business of firms with in-house laboratories and prospered by doing so. Among its largest customers in the 1940s and 1950s were Union Carbide, the Gulf Research and Development Corporation, Westinghouse, PPG, the H. J. Heinz Co., Texas Gulf Sulphur, the H. H. Robertson Company, the International Nickel Company, and Armstrong Cork Co., all firms with extensive research facilities. Surveys of sponsors conducted in 1952 and 1968 revealed that these and other clients used the Mellon Institute not as a substitute for in-house research but as a complement to it. Placing research projects at the institute put some distance between research personnel and the daily pressures of production, gave the sponsor the opportunity to obtain an independent check on its own research department, and allowed the sponsor to take "a long, hard look" at prospective employees.[78]

[75]E. R. Weidlein to Don D. Shepard, December 4, 1947, Mellon Trust Papers, "Mellon Institute, Department of Research in Pure Chemistry Reports" file.

[76]Donald D. Shepard to A. W. Schmidt, January 16, 1948, Mellon Trust Papers, "Mellon Institute of Industrial Research" file; MI Minutes, CMU, May 8, 1956.

[77]George A. W. Boehm and Alex Froner, *The Battelle Story: Science in the Service of Mankind* (Lexington, Mass., 1972); Weldon B. Gibson, *SRI: The Take-Off Years* (Los Altos, Calif., 1986); Charles N. Kimball, *Midwest Research Institute: Some Recollections of the First Thirty Years, 1945–1975* (Kansas City, 1985).

[78]Compton et al. (n. 32 above), app. B; apps. C-1 and C-3, "Report of the Joint Trustee-Staff Committee on University Policy for Sponsored Research" (n. 68 above), pp. 35–36. Mowery and Rosenberg, who have conducted a quantitative analysis of the sources of business of the Mellon Institute, Battelle Memorial Institute, and Arthur D. Little, Inc., find that such organizations became more dependent over time on clients with their own research facilities. They also found that contract research grew at a slower pace during the period 1910–40 than in-house industrial research and concluded that industrial research is generally more efficient when conducted in-house. See their *Technology and the Pursuit of Economic Growth* (n. 39 above), pp. 84–92. These findings explain why vendors like the Mellon Institute should have experienced slower growth than in-house research facilities,

Other observers attributed the institute's decline not to a reduction in the demand for research services but to a change in the nature of that demand.[79] The Mellon Institute was organized and managed by chemists; its staff and facilities reflected their disciplinary commitment. A chemistry-centered strategy led to rapid growth during the first decades of the 20th century, when America's chemical and chemical process industries expanded rapidly. But after World War II, as frontiers of industrial research shifted to such new fields as electronics and operations research, the institute's commitment to chemistry became a liability. The institute, by this account, was a victim of its inflexibility.

There is force to this explanation, although not so much as to account for the institute's precipitous decline. Management did forgo opportunities for diversification during the 1940s and 1950s. Yet it is worth noting that when the institute did attempt to diversify, by building a radiation laboratory in the 1950s, it found itself with a white elephant. The institute's $2 million investment attracted a few grants from the Atomic Energy Commission (AEC), but none of the industrial business that would have been necessary to make the laboratory self-supporting. It is even more important to recall that, while the chemical and chemical process industries were not growing as rapidly as the electronics industry in the 1950s and 1960s, they remained prosperous and research-intensive sectors of the American economy. By concentrating resources in chemistry and related sciences, the institute was targeting a large and proven market and focusing on fields for which its facilities were designed—a perfectly acceptable strategy for modest, albeit not scintillating, growth.

A comparison of the Mellon Institute's strategy during the 1950s and 1960s with those of its competitors may prove more fruitful in explaining its collapse than the rationalizations of its managers. The Mellon Institute differed from its more successful rivals, particularly the Battelle Memorial Institute, the Stanford Research Institute, and the Midwest Research Institute, in two important ways. Throughout the postwar era, and especially after its reorganization in the mid-1950s, the Mellon Institute was committed to intermediate and long-term research projects that entailed genuinely original research, albeit often of a technological rather than strictly scientific nature. The fellowship plan demanded that sponsors commit themselves for periods of no less than one year; in fact, the average duration of fellowships in the 1950s and 1960s was over six years. Richly endowed, staffed with some very able scientists, and

but they do not explain the absolute decline in industrial contracts that occurred at the Mellon Institute during the 1950s and 1960s.

[79]Compton et al. (n. 32 above); Schaefer interview with Warner (n. 59 above).

possessing a distinguished history, the Mellon Institute saw no need to chase business that could easily be handled by commercial consulting firms. Under Paul Flory and his successor, the Mellon Institute's bias toward open-ended, science-intensive research projects increased to the point where many forms of technological problem solving that had been acceptable to Weidlein were declared undesirable. Meanwhile, its rivals willingly accepted and indeed sought out all types of business, including many contracts for routine analytical chores that could be accomplished in months rather than years. Such work bulked large among the industrial contracts of these vendors.

Second, the Mellon Institute did very little to cement close ties to Washington during the first postwar decade. The Korean War and the arms buildup of the 1950s were crucial to the fortunes of Battelle, the Stanford Research Institute, and the Midwest Research Institute. Battelle became known as a center for metallurgical testing and research on the basis of its work for the AEC, Pentagon, and military contractors in the early 1950s; business from military research agencies rescued the Stanford Research Institute from likely dissolution in 1951; federal contracts accounted for most of the Midwest Research Institute's growth in the 1950s and 1960s. While its competitors were opening offices in Washington during the Korean War, the Mellon Institute focused instead on its traditional clients—large manufacturing firms.

Even so, the Mellon Institute was able to grow during the early 1950s, albeit at a slower pace than its younger rivals. Modest growth along established lines, however, was not enough for the Mellon Institute's new generation of managers. Witnesses to a spectacular expansion of federal research and development spending, they coveted a share of the grants and contracts that were going to universities and younger research institutes. Not only was federal money more plentiful than corporate funds, it also seemed to come with fewer strings attached. By changing its client base, the Mellon Institute could not only grow, it could also conduct more of the "fundamental research" that its new leaders valued above pedestrian fellowship work. To capture federal contracts, however, necessitated changes in the mission and constitution of the Mellon Institute. It would have to become more like a university. The logic that would lead the institute to renew its ties with a university and ultimately to become a willing participant in its own demise was in place.

Paul Flory and his associates understood that federal dollars were transforming American R&D, although they did not see very clearly how and why. Twenty-five years later, historians are only beginning to assess these changes. Federal funds financed an extraordinary expansion of America's research universities, created a network of national

laboratories, and greatly enlarged the size of the industrial research and development sector. They also altered the emphasis of American science and technology—by promoting work on military projects and space spectaculars, by nudging scientists into basic research of strategic importance to real and imagined national security needs, and by distracting industrial firms from commercial markets with lucrative contracts for esoteric military and space hardware. Much of the best work of recent years has focused on how such elite academic institutions as MIT and such highly visible disciplines as physics adapted to the new patronage.[80] But, as the historians of these subjects would readily acknowledge, federal patronage influenced a broad range of institutions and disciplines, even those that had only modest success in securing government grants. Like Aristotle's unmoved mover, federal patronage could elicit change without command.

Among the changes elicited was the homogenization of American research institutions and traditions in science and technology. Academic scientists were brought into closer touch with the needs of generals and defense contractors and, in the process, became more like engineers—that is, structuring their inquiry around technological and market demands, especially those of the military. Engineers, traditionally concerned with practical problem solving, became more like scientists—emphasizing formal knowledge over know-how and science over design. Universities became vendors of research, and long-time vendors of research strived to become more like universities. Corporations put their research laboratories on "campuses," and universities put their new centers for applied research in former factory buildings. Historians capture part of this process by referring to an acceleration in an older trend, the convergence of science and technology, although that formulation invites misunderstanding by suggesting a smoother and more comprehensive integration than occurred.

In fact, the "convergence of science and technology" sometimes resulted not in a successful merger but a takeover—a combination in which the values of one party largely supplanted those of the other. Historians focusing on elite institutions of science have given considerable effort to exploring the ways in which military funding altered academic science during the cold war. Yet, federal funds may have had even greater impact on communities of applied scientists and engineers serving civilian industry and on the institutions in which they worked. Tutored by scientists who insisted that desired technologies would emerge from research guided only by broad strategic goals, generals and legislators crafted a network of granting agencies that bolstered the

[80]See esp. Forman; Lowen; Leslie (n. 2 above).

authority of basic science—often at the expense of the humbler forms of knowledge held by industrial chemists and design engineers.[81]

Federal patronage, guided by expert opinion, created new institutions during and after World War II, but it also disrupted and undermined many existing organizations. By so doing, the government at once enriched and impoverished the nation's research facilities. The Mellon Institute, which had for decades supplied firms with know-how for innovation in consumer and industrial products, was one casualty. Others could be found in the nation's engineering schools, where experiment stations built before World War II to serve industry and to train students in the problem-solving traditions of practical engineering either closed or adopted new priorities after the war.[82] Like Flory, the administrators of these organizations came to see federal sponsors as more attractive than private. The resources of federal research agencies were greater; they expected less in terms of short-term, practical results; they seemed to have a more liberal view of basic research. Fundamental research became as much a slogan at these institutions as at the Mellon Institute during the late 1950s.

The Mellon Institute retained its original purpose of serving industry long after it had ceased to be fashionable; when its leaders finally decided to alter its goals they acted with unseemly haste. The institute's management had the option of staying the course in the 1950s; what it lacked, above all, was the determination to do so. The modest, problem-oriented work of the Weidlein era—work that represented the best of science to Andrew W. Mellon—fanned little enthusiasm in Compton, Flory, DuBridge, Killian, or Paul Mellon, who steered the institute into the 1960s, or in Stever, who took title to the institute in 1967. Intrigued by the prospect of abundant federal funds and convinced that basic science was, and ought to be, the fountainhead of technology, they sought to build an MIT by the Monongahela and instead dismantled Pittsburgh's preeminent institution of industrial research.

[81]Eugene S. Ferguson eloquently describes postwar changes in engineering traditions in *Engineering and the Mind's Eye* (Cambridge, Mass., 1992), pp. 159–68.

[82]Bruce Seely, "Research, Engineering, and Science in American Engineering Colleges: 1900–1960," *Technology and Culture* 34 (1993): 344–86.