Making History

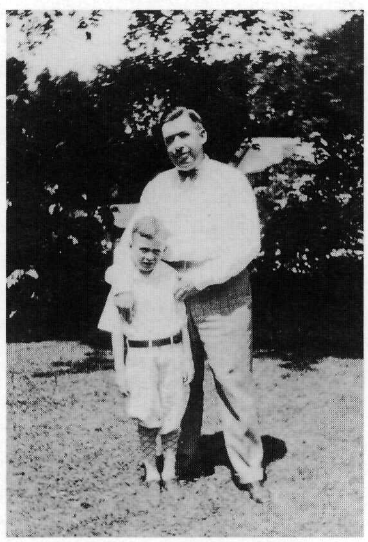
Quarks, Neutrinos, and Virtual Perfection: Interviews with Robert W. Galvin and Leon M. Lederman

Timothy J. Gilfoyle

Editor's Note: In June 1995, the Chicago Historical Society bestowed its first annual Making History Awards on a group of Chicagoans who have made historic contributions to the city. The inaugural group included Gwendolyn Brooks, John Hope Franklin, Robert W. Galvin, Leon Lederman, Judge Abraham Lincoln Marovitz, and Studs Terkel. Historian Timothy Gilfoyle has been conducting interviews with each of the honorees and, in the first of a series of articles, he explores the lives and careers of businessman Robert W. Galvin, former chairman of Motorola, Inc., and Professor Leon Lederman.

Above: Paul Galvin holding his two-year-old son Robert, 1924.

Below: Undated photograph of Paul and Robert Galvin. As a youngster, Robert often accompanied his father on business trips.



At first glance, Leon M. Lederman and Robert W. Galvin have little in common. Lederman—a Nobel Prize–winning physicist, raised in the Bronx by Russian immigrants, educated at Columbia University—has devoted the entirety of his professional life to the academy as a research scientist, laboratory director, and university professor. Robert Galvin, in contrast, was born and bred in the Midwest, the scion and heir-apparent of the founder of Motorola, Inc. As a seven-year-old, Galvin accompanied his father to company meetings and business trips across the country. If anyone ever was, Robert Galvin was "born" to be a corporate president.

A closer examination, however, uncovers common ground in these seemingly disparate careers in science and industry. As youths, for instance, both were born into devoted families of modest means. Paul Galvin's later success in manufacturing was not so apparent when his only child was born in 1922. "My father and mother [Lillian Galvin] moved to a little town in Wisconsin where I was born," remembers Robert Galvin. "In that community, he had gone to work with one of his boyhood acquaintances, . . . but that company went bankrupt in the course of the early months of my life in that little town. So my father and mother had to motor pennilessly to an aunt and uncle on the South Side [of Chicago], and that's where they kind of established our family, and gradually he caught on to having a means of taking care of my mother and myself."

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Above left: Robert and Paul Galvin, c. 1950. By 1956, the younger Galvin was president of Motorola. Above: Robert presented Motorola's "Twenty-Five-Year Service Pin" to his father on October 24, 1953.

Galvin describes his father's entrepreneurial sensibility as "almost genetic—he always knew he wanted to be in business." When Paul Galvin's partner elected to restart the company in Chicago, he joined him again. "And in not too many early years, the man's company went bankrupt," recalls Galvin. "On this occasion, however, there was a . . . product line of that company that had very inexpensive tools . . . . And my father acquired the tools at auction, walked across the street, literally, with about a half a dozen people, . . . and started a little company to make the battery eliminators." So began Motorola.

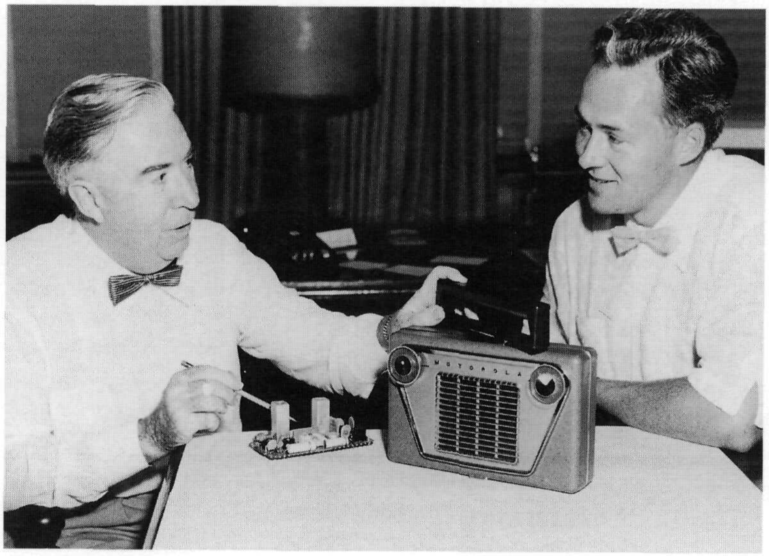
Lederman endured few of the economic insecurities and early failures that beset the Galvins. The Bronx, he remembers, "was a great place. It was a good place to grow up. I had schools within a few blocks of the house, a public school and a high school [were] nearby. I had friends. We had a wonderful city [New York] we could wander around in. There was no problem about traveling around the city, going into the subway and trying to get lost and coming out some unknown place and finding out it was a province called Brooklyn. . . . The schools were excellent. The teachers were very well educated and dedicated, and I remember many of them as being stimulating, exciting. That was a wonderful time to grow up."

Above left: Father and son share lunch in the Motorola cafeteria, 1954. Above: Robert Galvin with one of his teammates on an Evanston softball team, 1957. Galvin played second base.

Below: Paul and Robert Galvin discussing portable radio and chassis, c. 1955.

Robert Galvin was only six when, in 1928, his father founded the Galvin Manufacturing Corporation at 847 West Harrison Street. The market for battery eliminators, however, was quickly evaporating, as their main application for use in battery-operated home radios became obsolete. So Paul Galvin moved the company into an entirely new product line—the car radio. What was an unheard of and high-risk innovation in 1930 soon became commonplace in the expanding car culture sweeping the United States. The "first commercial auto radio" was the "Motorola," a name signifying both motion and the radio. The Motorola's popularity convinced Paul Galvin to rename the company after it in 1947.

After growing up in Rogers Park and Evanston, Robert Galvin attended the University of Notre Dame for two years before joining the Army Signal Corps in 1942. At the end of World War II, he returned to his father's company, working first as a stock boy and eventually as a production-line troubleshooter. Galvin quickly advanced within the ranks before being promoted to executive vice president in 1948 and president in 1956, only three years before his father died.



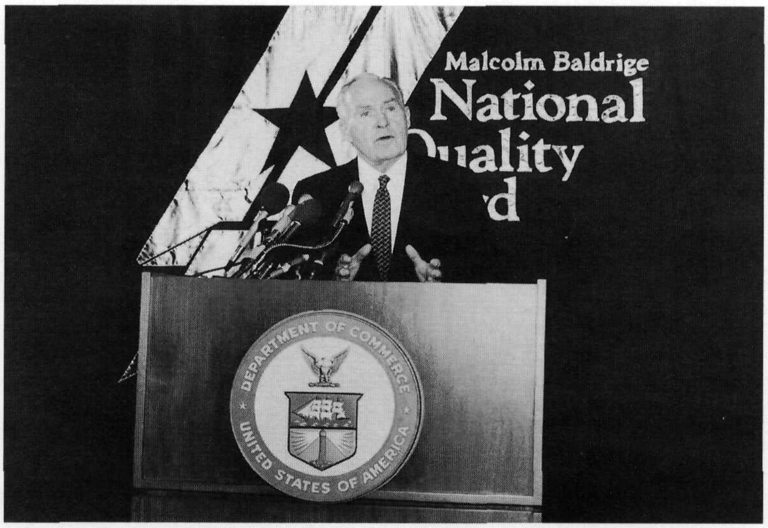
When Robert Galvin assumed control, Motorola was a $227-million-a-year company manufacturing car radios, walkie-talkies, solid-state color televisions, and phonographs. Over the ensuing three decades, he transformed Motorola into an $11-billion-a-year giant in electronics, employing over one hundred thousand people. Like his father more than a half-century earlier, Galvin completely abandoned several product lines for others. By 1990, Motorola had jettisoned its television business and was the leading manufacturer of two-way radios, cellular phones, pagers, and advanced dispatch systems for commercial fleets. It was the fourth-largest maker of semiconductors. Unlike IBM, which faltered upon entering a new technological phase (moving from mainframe computers to personal computers), Motorola nimbly moved from conventional two-way radios and TVs to cellular radios and pagers.

Motorola's success generated political appointments for Galvin. In 1970, he served on the President's Commission for International Trade and Investment. From 1982 to 1985, Galvin chaired the Industry Policy Advisory Committee to the U.S. Special Representative to the Multilateral Trade Negotiations. During that time, Motorola attacked Japanese producers for "dumping" cellular phones in the United States, a charge later upheld by the International Trade Commission. Galvin was later credited as a key architect in opening up the Japanese semiconductor market in 1986.

Carl Lindholm, Robert Galvin, and Bo Yibo, Vice Chairman of the Central Advisory Committee of the People's Republic of China, October 1986.

In 1990, Galvin retired as Motorola's chairman, but remains involved in long-term corporate planning as the head of Motorola's executive committee. Since then, he has been inducted into the National Business Hall of Fame and received the National Medal of Technology. Just prior to his retirement as chairman, Galvin was named one of the first recipients of the Malcolm Baldridge National Quality Award from the Department of Commerce (1989), specifically for making products with zero imperfections.

Indeed, future historians will most likely equate Galvin's tenure at Motorola with "virtual perfection." In 1978, after general sales manager Art Sundry pointed out numerous poor features in Motorola's product line, Galvin began emphasizing "total quality." In his words, Motorola adopted "a culture of intending that we never do anything that would dissatisfy the customer." Proponents sometimes referred to this as the "six sigma" philosophy. According to Galvin, "a sigma is a standard deviation from norm, and in statistical quality control parlance, if you can . . . build . . . a product or a service to where all the variations stay within six standard deviations from norm and fit your specifications, you will



In 1988, President Ronald Reagan presented Galvin with the Malcolm Baldridge National Quality Award (below). Left: Galvin addresses the U.S. Department of Commerce audience after the presentation.

have only 3.4 items outside the range of every million of something you do. This translates into, when you finally work the system right, a quality level of 3.4 defects per million. And we call that 'virtual perfection.'" Galvin admits that Motorola examined the ideas of W. Edwards Deming and other postwar industrial theorists, but in the end "we finally came up with . . . our own system. We were just either screwy enough or different enough [to] . . . let ourselves develop our own system."

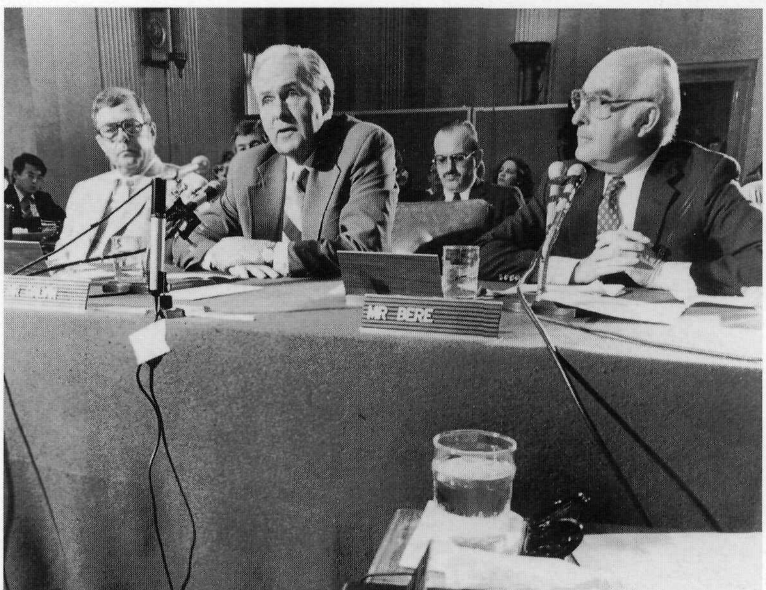
Virtual perfection departed dramatically from the scientific management techniques developed by Frederick Winslow Taylor early in the twentieth century. According to Galvin, "the six sigma systems . . . are quite different from the Taylor advocacy. . . . An overly simplified way of characterizing the Taylor approach was that it was a top-down phenomenon. If I measured your time, I could figure out how to tell you how to use your time better, and I would think of a system, and then I'd ask—I'd *require*—you to use my system."

Whereas Taylorism broke down and measured factory floor production to the individual worker, Motorola organized workers into independent "self-directed teams." According to Galvin, the teams "have no supervisor. Somewhere along the line there's somebody in the building that has some authority, and they see that person in terms of human interrelationships from time to time, but they may never get an order from that person." In contrast to Taylor's system, which imposed management directives on workers, Galvin asked: "Why don't we trust our people to determine from the bottom up what needs to be done? Once we've decided what needs to be done, we very often institutionalize that for a temporary period of time. . . . And we teach ourselves to follow that process so that we have a 'no mistakes' methodology of getting a function done, but in the meantime we're studying how to improve it, and the people who do the job are figuring out the improvements."

Galvin insists that virtual perfection not only rejected the principles of Taylorism, but actually saved immense amounts of time. "We now know that if we perform a function perfectly, we do it faster, or if we aim to do a function faster, we have to figure out how to get rid of the parts that cause the mistakes or the delays . . . and then we end up with better quality," claims Galvin. "You can almost start from either end of that pole and come to a very satisfactory result, but it depends on Mr. and Mrs. Everyman being the authors of what happens versus Mr. Taylor's plan prescribing for the rest of us." Characteristically, there is not a single time clock in any Motorola plant.

A major ingredient in Motorola's success and longevity has been its ability to adapt to changing conditions in the American economy. Consider the invention of the transistor in 1948, remarks Galvin. "We didn't know that was coming in 1947. The laser is a surprise. The computer is a surprise. In 1940, I didn't know that there would be a computer. . . . Now, those things are historical facts. They are events that took place, and they can be aggregated under the rubric of a surprise. The consequence of that is, that none of the companies that my father looked up to when I started here as a stock boy in 1940, are in any of the businesses that we're in today. Historically, most institutions do not adapt to the next surprises. That's a lesson about human beings. It happens to be an historical fact of the last fifty years. I believe you could find the same history the prior fifty years and the prior fifty years. We did adapt. I think there's something special about that. I

Galvin visits employees on the assembly line, 1959.



Above: At the 1971 Chicago Public Schools Math and Science Conference, Galvin talks with a student and a school official. Left: Galvin testifies before the U.S. Senate Foreign Relations Committee.

think that we had an orientation to 'renewal,' and every time something new happens, why can't we do it? It's a 'why not' versus 'why would anybody do that' or 'we're so satisfied.'"

While Galvin was searching for perfection in the workplace, Leon Lederman was looking for the same in his laboratories. After attending James Monroe High School, Lederman received his bachelor of science degree from the City College of New York in 1943 and his Ph.D. in physics from Columbia University in 1951. He spent the next twenty-eight years as a professor at Columbia, simultaneously serving as director of Nevis Labs from 1962 to 1979 and occupying the Higgins Chair in Physics from 1972 to 1979. Lederman then moved to Chicago to assume the directorship of the Enrico Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois.

Leon Lederman as a child.

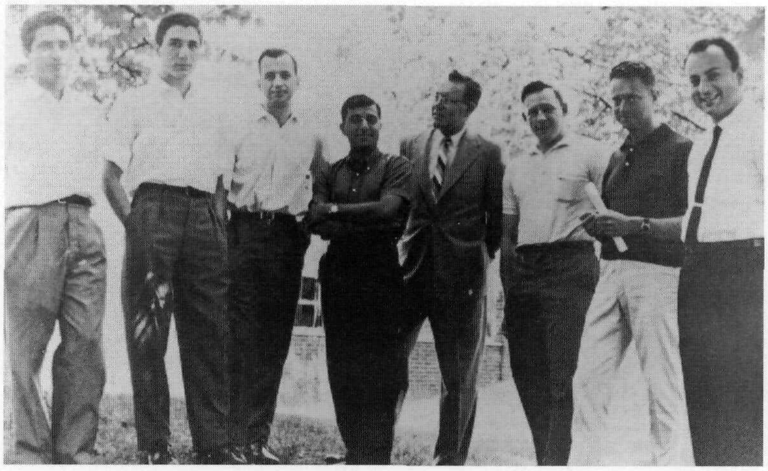
Lederman remains one of the most prolific and honored scientists of his generation, authoring more than two hundred publications on the properties and interactions of elementary particles. His most noted discoveries include the neutral K-meson particle (1956) and a new elementary particle called the "bottom quark" or "B Quark" (1977). Lederman was even involved in research leading to the invention of Doppler Radar. His numerous awards and honors include fellowships from the Guggenheim Foundation (1958–59), the Ford Foundation (1958–59), the Ernest Kempton Adams Foundation (1961), and the National Science Foundation (1967), as well as the National Medal of Science (1965), the Wolf Prize in Physics (1982), the Enrico Fermi Award (1992), and the presidency of American Association for the Advancement of Science (1991–93).

The capstone of Lederman's scientific career came in 1988 when he was awarded the Nobel Prize in physics for the discovery of the muon neutrino while working in 1961 and 1962 at Brookhaven National Laboratory on Long Island. Subatomic particles with essentially no mass, neutrinos pass effortlessly through objects, including the earth. Although the existence of neutrinos was suggested as early as 1931, Lederman was among the first to produce and study the particles in a laboratory. The research led to the use of neutrino beams to probe the structure of matter and helped demonstrate that there were fundamental symmetries among subatomic particles. In recent years, physicists have relied on neutrinos to develop theories uniting some of the basic forces of nature.

Upon assuming the directorship of Fermilab in 1979, Lederman remembers that "my first task . . . was to build that machine." "That machine" was the Tevatron—the world's first superconducting synchrotron and the most powerful particle accelerator. Sometimes called an "atom smasher," Tevatron is a superconducting magnet system contained within a 6.3 kilometer circular tunnel called the "main ring." Unlike other accelerators, Tevatron had the capability of "capturing" antiprotons in a storage ring. This allowed scientists to "gradually build up the number of antiprotons and squeeze them together—a very, very elaborate choreography of many rings and many technologies," says Lederman.

The Tevatron produced different kinds of antiprotons. Once inserted into the main ring, they ran in opposite directions from the protons. Circling each other in clockwise and counter-clockwise directions, the protons and antiprotons were accelerated to high energy speeds. "Then you make head-on collisions," states Lederman. "A head-on collision is much more violent than the standard collisions of a particle with something at rest. In other words, if a Mack truck hits a Ping-Pong ball, not much happens to the Ping-Pong ball; it just flies off, and nothing much happens to the truck. But if two Mack trucks collide head-on, then you get CB radios and horns and fenders . . . flying off in all directions. And violent collisions are the things we want to learn about, because they teach us more about physics."

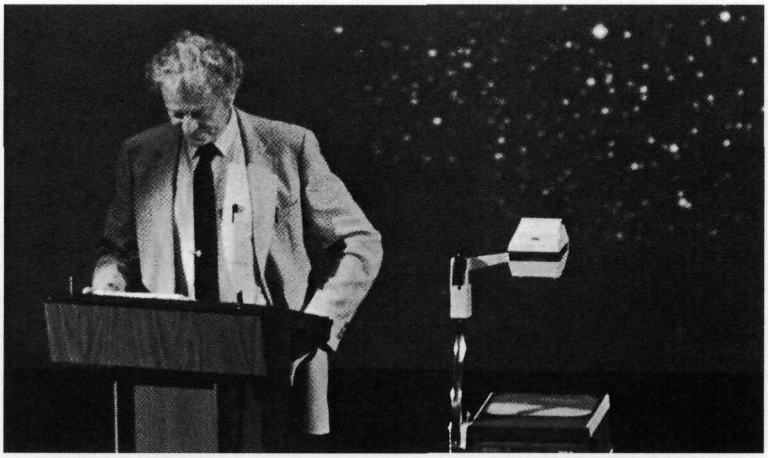
The Tevatron quickly surpassed its major competitor, the accelerator at CERN in Switzerland, playfully described by Lederman as "the laboratory we love to hate." CERN had successfully experimented with head-on collisions of antiprotons, "but the energy [at CERN] was a lot lower," remembers Lederman. So in the late 1980s, the Tevatron and CERN programs were competing to discover the "top quark." "At that point, the race was a draw," says Lederman. "Neither laboratory had found the top, but CERN had exhausted its possibilities, and Fermilab was just getting started. Because our energy was 2.5 times higher, . . . our possibilities were much higher. And in fact, in 1994, the Fermilab group published the first evidence for the top quark. In 1995 it was confirmed, so now we have a top quark, also found at Fermilab."



Above: The "two neutrino" experiment team, c. 1961. Brookhaven National Laboratory, New York. Opposite: Leon Lederman as a graduate student, c. 1946, with a cloud chamber, an apparatus used to see particles.

By some measures, the Tevatron epitomizes the vigor and vitality of American science in the Cold War era. Since 1991, Tevatron has been the world's most powerful source of data on elementary particles, "the workhorse of American physics and the most powerful machine in the world, especially now that we've lost the Superconducting Super Collider [in Texas]," argues Lederman. The Tevatron confirmed many predictions of the Standard Model, the central theory of elementary particles, allowing investigators to explore a domain where "no human eyeball has ever set foot," according to one mixed metaphor.

These specialized pursuits for "top quarks" and "virtual perfection" reverberated beyond the confines of Fermilab and Motorola. Both proved critical to the emergence of metropolitan Chicago's most significant "technoburbs" or "edge cities"—Naperville and Schaumburg. Since 1945, the combination of retail shopping



On his sixtieth birthday, Professor Lederman delivered the lecture "Innerspace, Outerspace" at Fermilab. Opposite: King Charles XVI of Sweden presents the Nobel Prize to Lederman.

malls, industrial parks, and professional office centers on the outskirts of cities—all linked together by interstate highways—have produced a new form of suburbanization. By 1994, for example, Schaumburg's 193,396 employees doubled the number found in individual downtowns such as Atlanta and Minneapolis. Furthermore, Schaumburg had more eating and drinking establishments than Portland, more Asian residents than lower Manhattan, and more professional corporations than downtown Houston. The construction of Motorola's new, 325-acre international headquarters in the 1970s was fundamental to Schaumburg's growth.

Naperville, thirty miles west of Chicago's Loop and a short distance from Fermilab, more than doubled its population during the 1980s, reaching 85,351. Established in 1831 (making it DuPage County's oldest community), by 1990, Naperville's employment base was supported by AT&T, Amoco, Dow Jones, Nalco Chemical, and Northern Illinois Gas. Much of this is centered along the seventeen-mile stretch of the East-West Tollway (Interstate 88; opened in 1958), sometimes called the Illinois Research and Development Corridor. Argonne National Laboratory, an outgrowth of the Manhattan Project research at the University of Chicago during World War II, was established southeast of Naperville in 1947 by the Atomic Energy Commission.

Fermilab, along with Bell Telephone Laboratories and the Amoco Research Center, was a key ingredient to the economic growth of the Naperville area after 1960. One hundred twenty-five proposals suggesting more than two hundred sites in forty-six states lobbied for the first "truly national laboratory" in the 1960s. Lederman notes that "the Chicago area proposal was considered the best. And it had the usual things in it: nearby major airport; people could get to it. . . . The climate was . . . satisfactory. The area had . . . a well-trained workforce, with the possibility of the existence of some local companies of high technology, . . . and the state was very good at saying, 'We will acquire the land. We'll pick up the land.' The land was very flat, and the geology was very good, and so there was no problem in having the site . . . thirty or forty feet underground."

In the end, Fermilab "just outweighed all the other proposals," argues Lederman. "It was taken seriously by the state and by a community that was very pro getting this machine there." Indeed, the state and local communities donated approximately sixty-eight hundred acres of land. Not surprisingly, when Fermilab opened, "it almost doubled the money—federal money—spent in this area, . . .

and lots of little high-tech companies sprang up around Fermilab. Certainly when I got there, we began a very close collaboration. We were used to each other and . . . this acted as an attractive feature for bringing government people in, because they could visit two labs with one blow. And so I think that was very positive, certainly very positive for the Chicago area, because some huge fraction, . . . 50, 60, 70 percent of the [federal] funds are spent locally, both for salaries of people who live there and for local contractors and local suppliers of various materials."

Fermilab, in fact, engaged in industrial production during Lederman's tenure. The Tevatron required over one thousand magnets, each twenty feet long. No manufacturer anywhere in the world produced such a product. "So we needed a factory," remembers Lederman. "We didn't really know how to make magnets, so the factory was an assembly line. That's what a factory is. And the assembly line would produce some terrible magnets, and we'd try to find out why they were so terrible, and we'd find out that we have to change this and that. We made the change in the tooling of the assembly line, and we kept going this way, hoping that at some point, a good magnet would be produced. And then we'd have two things: one good magnet and a mass production capability. . . . [W]hat fed the factory were materials from industry—the wires, the cables, the clamps, the stainless steel devices—all the things that were needed from industry, but we decided that this factory had to have intimate control . . . of it." When working at full capacity, the factory employed about two hundred to three hundred workers. "And it produced the thousand magnets and probably another two hundred or three hundred other kinds of superconducting kinds of devices that were needed for this thing. And most of the workers were people who were moonlighting. They were housewives and taxi drivers and off-duty policemen."

In the latter years of their careers, Galvin and Lederman became strong advocates of new and innovative forms of education. Beginning with the Motorola Training and Education Center, a corporate-training department that opened in 1981, Galvin was one of the first to introduce continuous training programs for employees in his American factories. Along with Motorola University and the Galvin Center for Continuing Education (established in 1986), Motorola employed new delivery technologies such as computer-based training, electronic publishing, satellite communications, and other interactive training systems to serve as both classroom training facilities and electronic distribution points. The system enabled Motorola employees to attend in-depth seminars without leaving their work locations. Satellite-transmitted seminars soon replaced business trips. By 1985, Motorola devoted more than one million hours to training twenty-five thousand of its ninety thousand employees worldwide, an investment of forty-four million dollars.

Galvin envisioned Motorola University supplementing the existing system of higher education. "We couldn't expect the general system to provide us with the particular things that we needed to have. To the extent that we also need the general system, we go out and use that. To the extent that we duplicate a little bit of what the general system does, it's because it fits compatibly with all these specialty things that we just have to have for ourselves. We had to train every employee. We have to train currently, every employee in the company, statistical quality-control principles. Well, if we went to the professor at [a] university, he would have, probably, a wonderful course in statistical quality control. We just want these nine pieces of that course, and we want it in four days, because that's what we need to be on one of these teams."

In 1986, Leon Lederman helped establish the Illinois Mathematics and Science Academy, one of the nation's first residential secondary schools created specifically for gifted students in the sciences. "Kids hate to be different," Lederman recognizes, "and very bright kids know they're different when they're in normal schools, and they react to that differentness in many different ways. But here, they're all the same. They're all . . . academically gifted and work together and collaborate and . . . have excellent teachers. While the building was a hand-me-down from the overbuilding of schools in the early '70s, it works, and it's a very splendid school."

Below: Lederman created Fermilab's Children's Center, a daycare facility for employee use, in 1981. Here he visits the center on his sixtieth birthday.

Lederman left Fermilab in 1989, first becoming the Frank E. Sulzberger Professor at University of Chicago and later the Pritzker Professor of Science at Illinois Institute of Technology (IIT). During that time, he founded the Teachers Academy for Mathematics and Science (TAMS) at IIT. TAMS had a goal of enrolling the seventeen thousand math and science teachers in Chicago's 550 public schools over a seven-year period for a sixteen-week intensive course introducing new and innovative ways of teaching science and math. If successful, Lederman hoped to duplicate the program in other U.S. cities.

TAMS, Lederman acknowledges, was an outgrowth of the school reform movement of the late 1980s. In 1989, there was "a lot of excitement about fixing the Chicago public schools. And one of the issues that was raised at some of the many meetings I attended was the fact that elementary teachers don't know how to teach math and science. And so that gave rise to the notion that we might try to help them as university people." With support from the Council of Presidents of local universities, the Department of Energy, the National Science Foundation, and the state of Illinois, TAMS sought to "retool" elementary education instructors teaching math and science. "[T]he vast majority," claims Lederman, "have no training in math and science, and too often approach the subject with the same fear and loathing as anyone else and transmit that to the kids, and that's terrible." Lederman admits the program had a "rocky" start. By beginning on a large scale, he believed, they hoped to quickly adapt to the demands to improve science education in the entire city of Chicago, "because we wanted to fix the whole city. This is the megalomania of the physicist, perhaps. . . . The federal government's getting harder and harder to count on, and so we're trying to switch over to state and local sources of money. That's where we are at the moment."

Both Lederman and Galvin express frustration regarding the failure of Congress to support ongoing, scientific research, specifically the Superconducting Super Collider (SSC) in Texas. Designed to be the world's largest and most sophisticated machine in the history of experimental physics, construction of the SSC began in the 1980s. But in 1993, fears of cost overruns and federal deficits induced Congress to abruptly halt funding. Virtually overnight, construction of the SSC stopped. Based upon his experiences as an evaluator of the National Science Foundation and other scientific enterprises, Galvin simply describes it as "a tragedy." Ultimately, "we will fail to learn on the early side some surprising revelations that science would likely have provided us, and we don't know what they are. . . . Discoveries are discoveries, and there is so much about this creation that we don't yet know. . . . But every four or five years we say, 'Wow! Wasn't that a great discovery that we made. I guess we know everything.' And then four years later we discover something else we were so surprised to learn. But people have their hearts in a different place. . . . Someday we'll have another tool, and we'll finally discover what might have been discovered in 1999 or 2002, and we'll dis-

Leon Lederman poses for the press on October 19, 1988, the day the Nobel Prize announcement was made.

cover it in 2022 or 2032. Too bad. A whole generation will have lost whatever the social, medical, economic benefits that would have been."

For Lederman, the rejection of the SSC had a more ominous meaning. "When it happened in 1993, the message wasn't clear," he concedes. Admittedly, the federal government needed "to rein in the budget and to solve the deficit. . . . But by now it's 1995, [and] we realize that was the first shot in a war that the government, but mostly the new Congress [elected in 1994], is waging against science. I think that science is now under tremendous stress across the board. It's not only particle physics; it's all physics and chemistry and biology."

According to Lederman, the long-term impact of this and related congressional decisions has catastrophic implications. "[W]e're damaging the future prospects of our children and grandchildren. No question about it. We have a certain capital of basic knowledge that we're running through in applying this to industry and technology. That's going to run out."

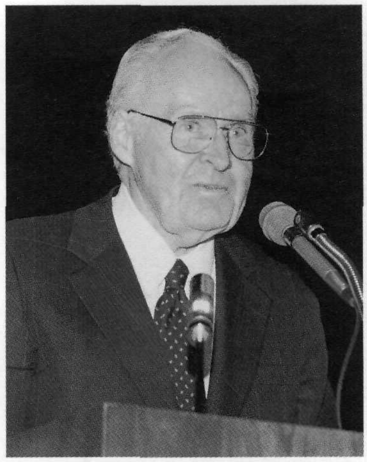
Ironically, these negative forbodings harken back to the educations of Lederman and Galvin alike. The former readily admits he profited from free public schools from kindergarten through college and later with graduate school and postdoctoral fellowships. "[A]t some point, . . . somebody made it easy for me. I had good schools. Who did that? Somebody did that. I had plenty of money to do my research. Who did that? How did that come about? Somebody did that." In Lederman's mind, the older generation of scientists are responsible for the next. Indeed, "at some point, you have to take your turn and see if you can do that for others, and I'll tell you, it's not easy," he admits. "I mean, those guys who did it all for me must [not] have had it easy, because this is very hard."

Galvin even attributes the origins of virtual perfection to his elementary education at St. Jerome's School in Rogers Park. "On a given occasion, whatever the grade was—fourth, fifth, or sixth, and I think the nun's name was Sister Mary Norberdette—the assignment . . . was announced that on Friday there would be a test on fractions to decimals, decimals to fractions. . . . And she said there was only one grade acceptable, and that was 100 percent. Well, of course, we all went home to our parents and raised Cain about that. . . . My recollection is about a third of the kids in the class got a hundred, and the rest of them all survived. . . . But the interesting thing about that [is] that here was a nun that was generating a standard, a level of expectation of perfection. And

. . . isn't it interesting that I was given the introduction to the right standard in fourth, fifth, or sixth grade when this nun said, 'There's only one acceptable answer—100 percent.' And now, finally, when I'm about fifty-five or sixty years of age, I've finally come to the realization, it's doable and it better be done. And so we set much higher standards in our [Motorola] corporation."

Both are distressed by the possibility that American society is unwittingly abdicating its historic commitment to scientific excellence. Galvin criticizes "those who would act rashly with regard to what funds are being allowed and afforded by the federal government, which for the most part, end up being applied in universities where the greatest research is done in our society." For Galvin, the question is clear-cut: "Will there be enough research being done in government laboratories? I am of the side that I would err on the side of doing more, because I think science finally seeds the next economic development."

Lederman passionately argues that American society is beleaguered by an educational crisis. "At the moment," he contends, "the American public is not terribly interested in schools." Lederman concurs with recent education critics who contend that the poor quality of public education has made the United States "a nation at risk." He admits that "although there are a lot of nice stories about successes here and there, the center of mass hasn't moved very much." Equally ominous is the public's ignorance about science. By one measure, 97 percent of the American public is illiterate in science. Lederman reminds Americans that "illiteracy is a shame of nations," a catastrophe in the making. For science to remain a positive force in American society, "we've got to raise that understanding so that we can preserve a democratic process, and maybe send some wiser and more knowledgeable people to Washington."



Above: Robert Galvin addresses the audience after receiving the Marshall Field History Maker Award at the Chicago Historical Society.

Below: Professor Leon Lederman accepts the Enrico Fermi History Maker Award from R. Eden Martin, Chicago Historical Society trustee.

For Further Reading

The most accessible sources on the ideas of Robert W. Galvin and Leon M. Lederman are in Robert W. Galvin, *The Idea of Ideas* (Schaumburg, Illinois: Motorola University Press, 1991); Kenneth R. Thompson, "A Conversation with Robert W. Galvin," *Organizational Dynamics*, 20 (Spring 1992); Leon M. Lederman, *The God Particle: If the Universe is the Answer, What is the Question* (New York: Houghton Mifflin, 1993); Leon M. Lederman (with David N. Schramm), *From Quarks to the Cosmos: Tools of Discovery* (New York: W.H. Freeman, 1988); Leon M. Lederman, "The Tevatron," *Scientific American* (March 1991), 48–55; Leon M. Lederman, "Blackboard Bungle," *The Sciences* (Jan.–Feb. 1995), 16–20. Robert Galvin and Leon Lederman await their biographers.

Illustrations

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