

I. I. RABI AS EDUCATOR AND SCIENCE WARRIOR

Isidor Isaac (known to the world simply as I. I.) Rabi was, first of all, a superb physicist. He headed a marvelously productive laboratory at Columbia University, with brilliant students and postdocs. During World War II, he was associate director of the MIT Radiation Laboratory and a senior adviser to J. Robert Oppenheimer at Los Alamos. After the war, he continued to work as a physicist, and as a consultant to government, laboratories, and international organizations. He became a most respected senior statesman of science. Always the voice of reason and of moral authority, he sometimes succeeded in hiding his commitment behind his down-to-earth humor.

But there are two additional facets of Rabi, apparently separate from his scientific and political pursuits: He was an eloquent spokesman for education with the highest standards and a wide scope, and he was a passionate warrior in defense of the view that a modern culture must prominently include science. Rabi even had the courage to give one of his books the title, *Science: The Center of Culture*.¹

It is on these two aspects that I concentrate in this essay, using preferably Rabi's own words to indicate his cast of mind. I also try to show that Rabi's interests in education and in the place of science in culture were not two different enthusiasms, set apart from his views on physics and statecraft. Rather, I contend, they were organically part of his coherent vision of his mission on this Earth.

Trouble with their God

I caught my first glimpse of the secret source of Rabi's immense and effective energy when I was chatting with him one day in the early 1960s about a physicist who had been one of his students, a man who later enjoyed being a rather rough customer. With an impish glance, Rabi said: "Well, you must remember that there are two kinds of physicists: One kind turned to physics because in early life they had trouble with their radio kits; the others became physicists because they had trouble with their God. Our friend . . . well, he is of the first kind."

I didn't understand until much later how serious Rabi's remark was. At the time, I took his reference to the second type to refer to people like Albert Einstein,

Rabi the educator argued passionately for science as an integral component of our culture. For Rabi the statesman, Benjamin Franklin was the figure in American history most worthy of emulation.

Gerald Holton

who explained that as a boy he had experienced a period of "deep religiosity [before] the reading of popular scientific books" led him to leave—though never completely—what he called "the religious paradise of youth," in favor of the less "comfortable and alluring" paradise of scientific thinking.² I return shortly to Rabi's remark.

A year or two later, I had another talk with Rabi. In the post-Sputnik early 1960s, I had been asked by the National Science Foundation to develop a national physics course for high schools, one meant not only for aspiring scientists. That was how the *Project Physics Course* started, in which we integrated physics with some of the history and the methods of science, to show that the evolution of physics was an important part of the rise of modern Western civilization, and also that even the historic grand masters of our science initially had considerable trouble developing their counterintuitive ideas.

With the intention of asking Rabi to head the advisory committee of our project, I described its intended approach. To my surprise, he agreed immediately. It seemed to touch something that he had already been deeply convinced of. He accepted my request, and moreover allowed us to print, at the top of the first page of the text, the following impromptu remarks, as I recorded them:

Science is an adventure of the whole human race to learn to live in and perhaps to love the universe in which they are. To be part of it is to understand, to understand oneself, to begin to feel that there is a capacity within man, far beyond what he felt he had, of an infinite extension of human possibilities. . . .

I propose that science be taught, at whatever level, from the lowest to the highest, in the humanistic way. It should be taught with a certain historical understanding, with a certain philosophical understanding, with a social understanding and a human understanding, in the sense of the biography, the nature of the people who make this construction, the triumphs, the trials, the tribulations.³

Anticipating the science wars

I should have remembered that, back in 1955, Rabi had entitled his Morris Loeb Lecture at Harvard "Science and the Humanities." In that lecture, foreseeing the rise of what are now called the science wars, Rabi spoke up for the blending of "these two traditions [science and the

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humanities) in the minds of individual men and women.” That was two years before C. P. Snow’s famous lecture on the intolerable gap between what he called the two cultures. Indeed, Snow later admitted privately that while Rabi was in London in 1957, Rabi had been “the man who gave me the idea for the two cultures.” The source of this information is John Rigden’s masterly biography, *Rabi, Scientist and Citizen*,⁴ to which I refer often in what follows.

Another eye-opening source I found, as I was trying to understand Rabi more fully, was the interview he gave in 1963 to the Quantum Physics Oral History Project, a unique joint activity of the American Physical Society and the American Philosophical Society. The first question the interviewer asked was how Rabi initially got into quantum physics. Rabi’s reply may well have surprised his interrogator:

I was raised in a very Orthodox Jewish family with a great religious influence on me, and it is my view, perhaps that my scientific interest came from the religious . . . [especially] the first chapter of Genesis. . . . On the other hand, my favorite reading and my best subject in high school was history, a subject in which I got very high grades very, very easily and without any work at all; history was in that sense my top subject, although my interest was in science, which, I think, came about from Genesis. . . . [Also] my first reading of the Copernican theory of the explanation of the seasons and so forth left me with a scientific interest which never flagged, and I can still contemplate the Copernican system with a tremendous amount of pleasure.⁵

What a mixture of Genesis, history, and science! But it makes sense. Rabi was the first-born child and only son of an impoverished family of Orthodox Jews, who took him from a small town in Galicia to the Lower East Side of Manhattan soon after his birth in 1898. Going to Hebrew school from age three, he quickly learned to read, above all, the Bible; and he always delighted in the Bible stories.

The practices of strict Orthodox Judaism, from childhood on, include praying to God throughout the day, from opening one’s eyes in the morning, on washing one’s hands, and into the night. Rabi stopped following these rituals, probably by his teens. Eventually he took a position similar to Einstein’s concept of “cosmic religion,” turning against the institutionalized forms of religion which, he thought, tend to divide people and produce conflict.

But something important remained from his upbringing. As Rabi told it:

There is no question that basically, somewhere way down, I am an Orthodox Jew. . . . To this very day, if you ask for my religion, I say “Orthodox Hebrew,” in the sense that the church I am not attending is that one. . . . It doesn’t mean I am something else.⁶

Elsewhere he said, “My early upbringing, so struck by God, the Maker of the world, this has stayed with me.” (ref. 4, p. 21) In his own way, Rabi remained God-struck throughout. He once reminisced:

[Physics] filled me with awe, put me in touch with a sense of original causes. Physics brought me closer to God. That feeling stayed with me throughout my years in science. Whenever one of my students came to me with a scientific project, I asked only one question, “Will it bring

you nearer to God? (ref. 4, p. 73)

In my research on scientists, I try to be alert to the resonance between their cultural backgrounds and their later achievements. In Rabi’s case, the resonance is clearly present. By the time Rabi was a teenager, he had developed a mind-set that guided him throughout his life, a worldview that looked for transcendent and elegant order and coherence, whether triggered initially by the Bible or by the Copernican system. At age 13 or 14, having become aware of the disparities and inequities in the social world, Rabi even toyed briefly with Marxism, saying later, characteristically:

What Marxism gives you is a view of society and a view of history—an integrated view. It’s mostly wrong, but it is a view. You get the habit from this of thinking of things in a holistic way. You see connections. . . . I had the advantage of a religious background. Religion is also a system that encompasses everything, but it has something that Marxism doesn’t have: religion has color and class. That whole idea of God, that’s real class. (ref. 4, p. 26)

Against this background, let us now ask in what sense Rabi was an educator. Young Rabi, without resources or mentors, had the drive and unbounded curiosity to become a self-educator—an old theme among major scientists in their youth, from Faraday to Einstein. Rabi would typically read four or five books a week. He was especially fascinated by history. (ref. 4, p. 29)

Rabi at college

After enrolling at Cornell University in fall of 1916 as a chemistry major, he was talented enough not to have to labor over his courses, and so he could follow his widespread interests on his own. He reported later,

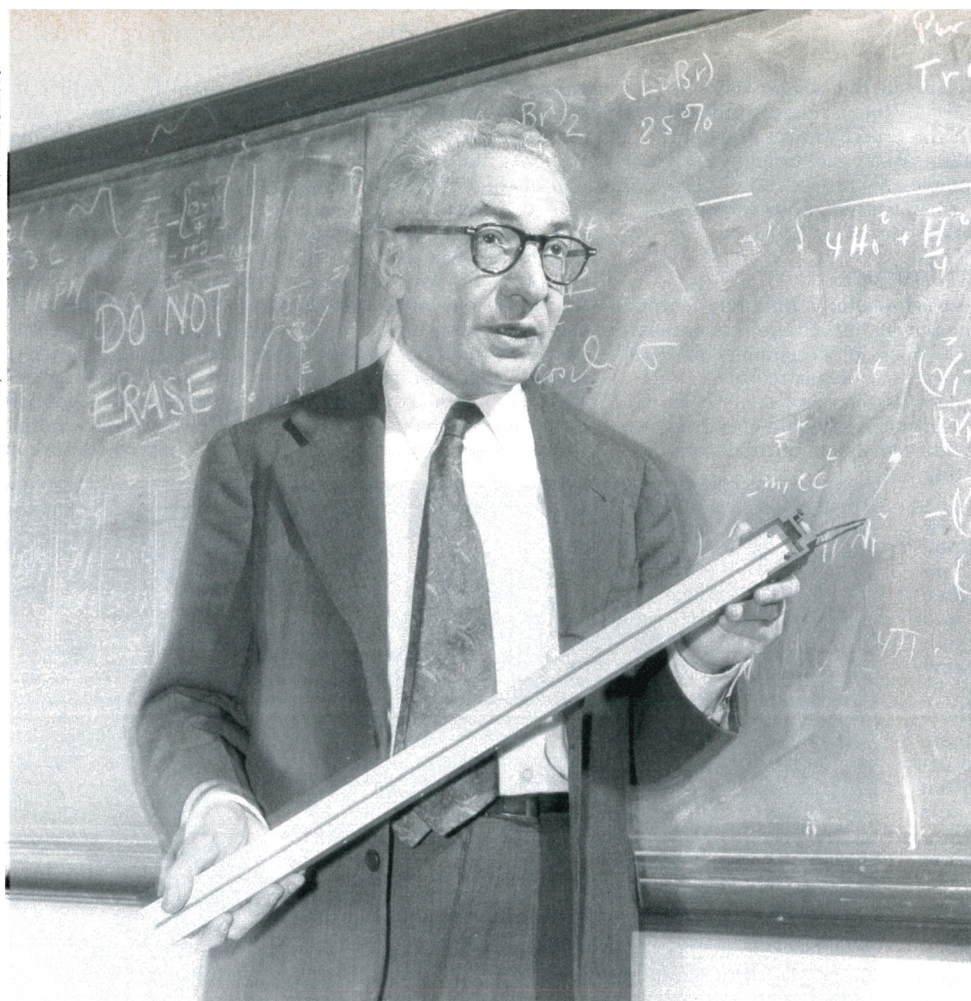
If I was taking a course in qualitative analysis, I might be reading Freud. I did an immense amount of reading. In this strange way, without taking courses, I got myself a liberal education. I would read about the history of the subject I was taking, the history of science. . . . [Mine was a] more relaxed approach, the historical, more synoptic view; I got more pleasure out of the thing than the others did, and I didn’t have to do as much work. (ref. 4, p. 32)

To Lee DuBridge he said once, while reminiscing about his undergraduate education, “If you decide you don’t have to get A’s, you can learn an enormous amount in college.”⁷

So Rabi as educator was, first of all, his own educator, driven by his wide-ranging desire to understand. That helped him also to realize that the part of chemistry he liked most was called physics. What drew him to physics was, not surprisingly, again the unifying power of a few great ideas and laws.

When, at age 25, he started his graduate studies in physics at Columbia University, he discovered the new physics coming from Europe, not yet through the courses at Columbia, but by reading European physics journals. Typically, once again, Rabi organized a self-education group of fellow students, including Francis Bitter, Ralph Kronig, S. C. Wang, and Mark Zemansky. Rabi commented on this later: “I organized [this] group to study modern physics, that the faculty didn’t teach. . . . I was getting around to things I had done as a little boy, when I organized a group.” (ref. 4, p. 42)

These study groups became marathon sessions, from 11 a.m. into the late evening, discussing, for example, the



I. I. RABI (1898–1988)

Arriving in Europe in the summer of 1927 on a traveling fellowship, Rabi met and observed many of the most productive scientists of the time: Schrödinger, Niels Bohr, Max Born, Otto Stern, Werner Heisenberg, Wolfgang Pauli, Arnold Sommerfeld, and P. A. M. Dirac. From these men, as he put it later, he learned what physics should be: taste, insight, standards to guide research, “a feeling for what is good.”

In addition to finding, in Stern’s laboratory, the first steps to his own later scientific eminence, Rabi came to a realization of historic consequence: As was generally agreed, America at that time lacked people at the top level in physics. But Rabi also noticed shrewdly that

papers in the latest edition of the *Zeitschrift für Physik*. But Rabi also continued his routine of reading on his own, including the historical classics of science. In this way, he could later say that “One day I happened to be reading, for sheer pleasure, Maxwell’s [1873] *Treatise*” (ref. 4, p. 43) in the library. It gave him the clue for quickly measuring the magnetic susceptibility of a crystal that was to be the center of his PhD thesis project.

Similarly, when, at the end of 1926, Rabi got stuck while trying to apply Erwin Schrödinger’s new version of quantum mechanics to molecular systems, he was rescued while reading, for pleasure, a book by the 19th-century German mathematician Karl Gustav Jacobi. There, Rabi found the equation he had been unable to solve, with Jacobi’s solution in terms of a hypergeometric series. (ref. 4, p. 52) So it becomes clear that Rabi was not just trying to be fashionable when, in his later pronouncements, he insisted that history and a broad-based approach should have their place in good science teaching.

Postdoc in Europe

In 1927, a new theme enters our account. Like so many other American scientists in the 1920s, Rabi felt that, after getting his doctorate, he had to go to Germany to learn the new quantum mechanics and experimental skills at first hand—above all, to acquire the taste and style of doing physics on a grand scale. As he put it, he already knew the lyrics, but he had to learn the melody.

he and many of the other young American physicists then studying in Europe were as good as any of the European physicists in the rank just below the top level.

That realization opened his eyes to his next mission. As he put it later, “What we needed were the leaders.” (ref. 4, p. 63) During his two years in Europe, Rabi also grew increasingly annoyed at the general contempt toward American physics he encountered. Of course, this provoked him to action. Other Americans, among them Ed Condon and Bob Robertson, had also been irked by such derogations. Rabi called on them, and they made a compact that “they would put an end to the second-class status of American physics.” (ref. 4, p. 63) When they returned to America, they would not only do important physics in the proper style, but they would also undertake to become leaders of the field.

That was perhaps one of Rabi’s most propitious decisions as a science educator in America. It released an immense amount of energy that not only propelled American laboratories to do superb work, but later also took on operational meaning in Rabi’s interest in better science education at all levels. Rabi commented:

We said we were going to really do something, very definitely in our generation, and we did, because ten years later the *Physical Review* was the leading journal in the world. . . . When we came back, my generation, Condon, Robertson, Oppenheimer, myself. . . people like Van [Vleck]

... we just sort of changed the whole works in this short time. I had half the graduate students in the department at the time I was an assistant professor [at Columbia]. We sort of brought back the white man's magic, so to speak. ... The general democracy which we had, allowed young people to come forward. (ref. 5, p. 29)

No more three-hour lunches

As the only son in an Orthodox family, Rabi had learned early that he could, as he put it, "intimidate" his parents. Now, on returning to New York in the summer of 1929, he did it to the Columbia physics department:

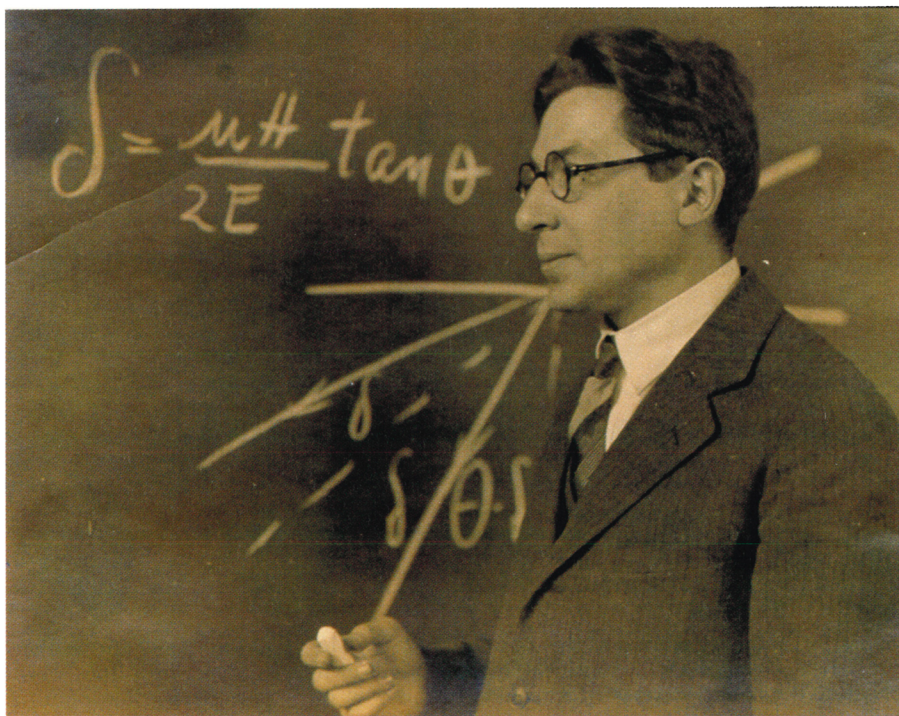
I was all over the place as soon as I came back [from Europe]; you see, that's the kind of person I am. ... Suddenly the whole damned department started working hard whereas they hadn't before. They said "Goddamn it, Rabi, before you came here we used to have three hours for lunch and play bridge!" ... I think I made life interesting from the scientific point of view ... ideas for experiments, meanings, how paradoxes are explained, what quantum theory means in this situation or that situation. People just got very interested. We worked every day of the year with the exception of three or four days, New Year's day and Christmas day, and so on. ... Once I got going on those experiments, this was a day and night job, all the time. I had about 15 students to keep going. (ref. 5 pp. 35-38)

With students and postdocs of the caliber of Norman Ramsey, Frank Press, Leon Lederman, Jerrold Zacharias, and many others, Rabi was ideally positioned to inspire and set standards for a whole new generation of top-flight scientists. To be sure, his molecular beams research, into which he had thrown himself passionately, left little time for preparing lectures on quantum mechanics. So, throughout the 1930s, many of his students found his classroom lectures confused and disorganized. But they learned from his improvised groping at the blackboard and from the excitement he exuded, which made them rush to the books and to private discussions, learning how to gain confidence.

Press said about a course he took from Rabi: "If he made a mistake, a very simple mistake ... the next thirty minutes or so would be spent trying to find that mistake. However, in terms of giving perspective to the significance of a particular discovery, the state of the art, the humanistic aspects of science, a sense of excitement—he was without peer." (ref. 4, p. 71) And in any case, Rabi's door was always open after class for discussion. It may have been said of him at the time that he was simply an awful lecturer; but he also was a great teacher, and in that

respect fitted into the charismatic chain from Kepler to Helmholtz and Rutherford, who all shared that mixed gift.

Rabi was particularly effective in conveying to his students and coworkers a sense of experimental elegance and of the criteria for choosing a research subject. There was also Rabi's long-range effect as educator through his influence on the work of other physicists in a great variety of fields, as demonstrated by the well-known "Rabi Tree," (ref. 4, p. 12) which illustrates the astonishing flowering and branching of his intellectual offspring, and through the application of his ideas, such as the magnetic resonance method, not only in physics but also in chemistry, biology, and medicine. He may not have liked to get involved in an experiment with apparatus he had not built, but he was usually the guiding force on the concept of the experiment, the equipment, the interpretation of



RABI AT COLUMBIA in the early 1930s.

MARK ZEMANSKY, COURTESY AIP EMILIO SEGRE VISUAL ARCHIVES

results, and, above all, the standards and the choice of problems.

A civic scientist

With the end of World War II, Rabi took on an additional role. His political self-education during the Los Alamos period had convinced him that "the world had changed, and the future would be something which would not take care of itself." It would require some "practical politics." (ref. 1, p. 71) With the authority that came with his Nobel Prize of 1944, and the public understanding of the role physicists had played in helping to rescue Western civilization from its enemies, Rabi became a public person, a civic scientist.

That role came to Rabi quite naturally. He felt that intellectuals should live a life beyond their research specialty and, in addition, that they now had a particular ethical responsibility. As he put it, now that technological advances "have made it absurdly easy to kill human beings ... [the] disinterested search for objective truth," because of the products to which it might lead, requires also "the

shouldering of social responsibility.” (ref. 1, pp. 25–26) Significantly, these words appeared in one of his first essays for a wider public—in the October 1945 issue of the *Atlantic Monthly*.

From then on, he would speak up again and again, not least on politics and ethics—for example, on the moral revulsion he felt at President Truman’s decision to develop the H-bomb, and at the persecution of Oppenheimer.

Others have written about his influence on the politics of the time, on his prescient and vigorous advocacy for a European joint center for science (which was to become CERN), and on his role in initiating the Atoms for Peace conferences held in Geneva in the 1950s, which brought together a great confluence of scientists of all ages, from both sides of the Iron Curtain. He became one of the most effective statesmen of science that America has ever had.

Science and culture

I want to conclude with one aspect of Rabi that originated in the holistic, synoptic point of view acquired in his early

Rabi put it, science is a counterforce to what he called, in 1964, “the anti-Galileans.” (ref.1, p. 113) In that lecture, and in another three years later, Rabi took on the counterculture and antiscience movements, then already in full force. He had lived through two-thirds of a century marked by irrationality on a vast scale. Unlike so many other scientists too preoccupied or timid to speak out on this subject, he called the “battle rag[ing] on every campus,” the war against science, “a symptom of both ignorance and of a certain anti-rational attitude which has been the curse of our century. . . . It is a sort of poison which undermines the self-confidence that leads to the highest development of a rich culture.” (ref. 1, p. 32) In yet another lecture, he asked for dedication to build “a unified culture in which the sciences describe a world which is alive with people and with feelings, and the humanities describe a world in which the physical universe is not inert matter but rather is a part of the development of the human spirit.” (ref. 1, p. 42)

▷ Science teaches how to think objectively, rationally, and

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RABI AND ENRICO FERMI
at a Long Island beach in 1953. Behind them on the right is Mrs. R. D. Hill, and on the left is a truncated Robert Serber.

youth and became ever more mature: a passionate commitment to safeguarding a rightful place for science as a necessary and liberating aspect of the total culture. In lecture after lecture, Rabi was clear and specific about the various reasons why this had to be so. Let me summarize his main points:

▷ Science can act as a unifying force for all humanity, and thereby it counteracts the divisive and destructive tendencies of almost all other human enterprises: “Science is the greatest decentralized, undirected cooperative effort of all time . . . among people of the most diverse origins and cultures.” (ref. 4, p. 260) It brings together people of very different backgrounds and loyalties in a common search for truths.

▷ Science can act as a personally ennobling activity. As Rabi said in the quotation we used in the *Project Physics Course* text, “Science is an adventure of the whole human race, to learn to live and perhaps love the universe in which they are. To be a part of it is to understand, to understand oneself, to begin to feel that there is a capacity within man far beyond what he felt he had, of an infinite extension of human possibilities.”³

▷ Scientists have to defend themselves against enemies who fail to see science as part of one unified culture. As

therefore productively for solving the problems of society—especially in a democracy. Speaking at Yale in 1962 on “Science and the Liberating Arts,” Rabi proposed that science

is the first of the liberating arts and perhaps the model for the others . . . [because it] will teach us to look at our problems objectively and solve them in the manner best suited to our needs and possibilities. . . . Scientific truth and the scientific adventure can set the standard for our contemporary striving for a just and meaningful world. (ref. 1, pp. 45–47)

After all, there is hardly a problem of government that does not have an important scientific aspect. (ref. 1, p. 90)

▷ Finally, science can be a good preparation for a useful life outside science: “If science were taught more humanistically in the schools and in the universities, it could become a foundation for any career, not only teaching or research.” (ref. 1, p. 92) That would add “vigor to our civilization.” Rabi asked:

Where does [one now] look for leadership, support, and implementation? . . . Unfortunately, [one looks] to a Congress and Executive. . . . They



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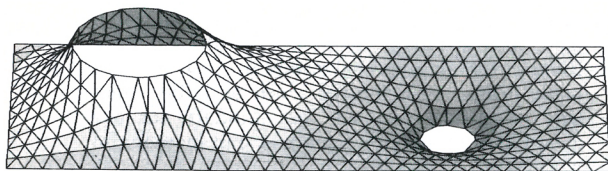
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are often ignorant if not definitely hostile to the finest flower of our culture, suspicious of intellect and reason, addicted to words without content or context. No wonder we are in trouble. (ref. 1, p. 48)

As Rabi put it as early as 1946, he resented that "to the politician, the scientist is like a trained monkey who goes up to the coconut tree to bring down choice coconuts." (ref. 1, pp. 139-140) He added that intelligent people well educated in science and the humanities, including "artists, writers, economists, sociologists" and others, should "enter into political life" and run for public office, to supplement the "present incumbents, the lawyers and businessmen." (ref. 1, pp. 48-49)

But Rabi was by no means guilty of favoring a takeover by scientists. With his balanced judgment, Rabi agreed that President Eisenhower was right, in his famous farewell address, to have warned against the "danger that public policy could itself become the captive of a scientific-technological elite." (ref. 1, p. 81)

I conclude with this thought: Throughout Rabi's dazzling career during this trying century, that self-educated, God-struck youngster within him was constantly motivated to wise and courageous service, on behalf of both science and the country he loved. I think he had before his eyes a model. In a 1964 lecture, he confessed: "My ideal man is Benjamin Franklin—the figure in American history most worthy of emulation. . . . Franklin is my ideal of a whole man." (ref. 1, pp. 111-112) Initially a craftsman, Franklin had become one of the greatest scientists of his time, and also a successful diplomat and statesman. "Where are the life-size, or even the pint-size Benjamin Franklins of today?" asked Rabi poignantly. From what we know of Rabi, it is clear that he himself is a worthy, life-size model for our own turbulent times.

This essay is an expanded version of a talk I gave at the special Rabi session at the American Physical Society's centennial meeting last March in Atlanta. In the preparation of the talk and this article, my chief reference sources have been: John Rigden's 1987 biography, Rabi, Scientist and Citizen; I. I. Rabi's Science: The Center of Culture (1970) and his My Life and Times as a Physicist (1960); Interviews recorded by the Quantum Physics Oral History Project; Columbia University's 1970 tribute to Rabi on his retirement, entitled A Festschrift for I. I. Rabi, edited by Lloyd Motz, and published in the 1977 Transactions of the New York Academy of Sciences; Norman Ramsey's biographical tribute to Rabi for the National Academy of Sciences Memorial Series; Ramsey's book, Spectroscopy with Coherent Radiation; Rabi's 1982 Oersted Lecture; and Rabi's essay in Oppenheimer, published by Scribner's in 1969.

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