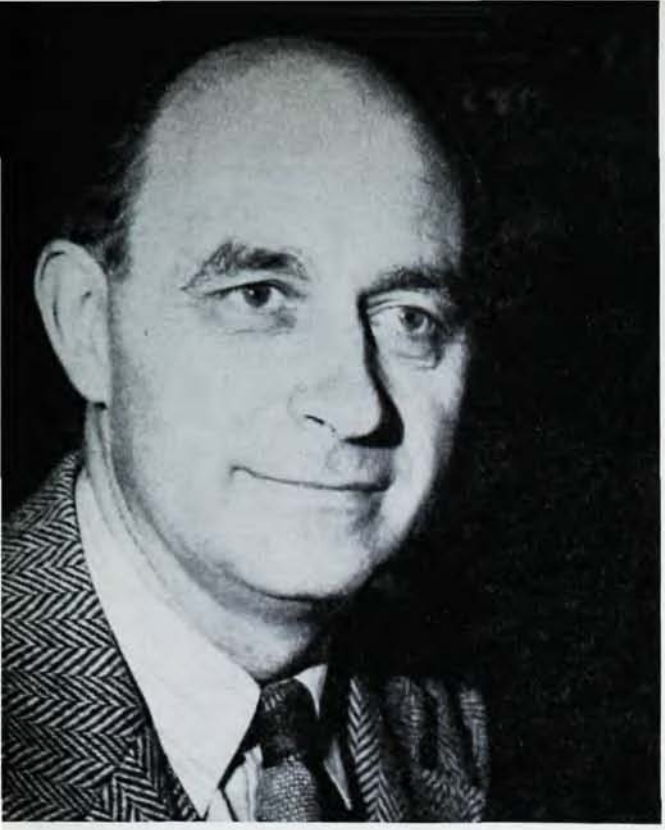

Born and educated in Italy, Enrico Fermi came to this country in 1938 instead of returning to Italy from Stockholm, where he had just received the Nobel Prize. Shortly before his death he was named by the AEC to receive a special $25,000 award for his outstanding contributions to the atomic energy program.

ENRICO FERMI

1901 - 1954

The untimely death of Enrico Fermi on November 28th deprived the world of one of its most brilliant and productive physicists. The following remarks by three of Fermi's friends and colleagues were made on the occasion of a memorial service held on December 3rd in the University of Chicago's Rockefeller Memorial Chapel. Samuel K. Allison, professor of physics and director of the University's Institute for Nuclear Studies, presided at the ceremony.

A Tribute to Enrico Fermi by S. K. Allison

WE are here to honor the memory of Enrico Fermi, Charles H. Swift Distinguished Service Professor of Physics at this University during the last decade. I shall try to express the sentiments of his associates here in the Institute for Nuclear Studies. Actually, the Institute is *his* Institute, for he was its outstanding source of intellectual stimulation. It was Enrico who attended every seminar and with incredible brilliance critically assayed every new idea or discovery. It was Enrico who arrived first in the morning and left last at night, filling each day with his outpouring of mental and physical energy. It was Enrico's presence and calm judgment, and the enormous respect we had for him, which made it impossible to magnify, or even mention, any small differences among us, such as can arise in any closely associated group. It was at Enrico's personal and urgent request that I took on the chore of directing the Institute in its routine affairs.

It is a completely objective statement, not at all prompted by the emotion of this occasion, to remark that every one who had more than a trivial acquaintance with Mr. Fermi recognized at once that here was a man who possessed a most extraordinary endowment of the highest human capabilities. We may have seen his physical energy before, or his basic balance, simplicity, and sincerity in life before, or even possibly his mental brilliance, but who in his lifetime has ever seen such qualities combined in one individual?

In my attempts to understand him, with his completely successful adjustment to the life of today, and his leadership in it, I conclude that one reason such men are so rare is that it is so improbable that such a combination should be formed.

I would like to recount one incident showing Enrico in action. During the war, Professor A. H. Compton, Enrico Fermi, and I were travelling together to visit the Hanford Plutonium Plant in the State of Washington. Mr. Compton and Mr. Fermi were so valuable that they were not allowed to travel by air; I was expendible, and could have flown, but was on the train with them for company. The hours seemed to drag crossing the mountains, and Enrico, who always disliked travelling, was restless and bored. After some long silences, Mr. Compton said:

"Enrico, when I was in the Andes mountains on my cosmic-ray trips, I noticed that at very high altitudes my watch didn't keep good time. I thought about this considerably and finally came to an explanation which satisfied me. Let's hear you discourse on this subject."

Enrico's eyes flashed. A problem! A challenge! Something to work on! Having been in several such situations before, I relaxed and prepared to enjoy the fireworks that would surely follow. He found a scrap of paper and took from his pocket the small slide rule he

always carried. During the next five minutes he wrote down the mathematical equations for the entrainment of air in the balance wheel of the watch, the effect on the period of the wheel, and the change in this effect at the low pressures of high altitudes. He came out with a figure which checked accurately with Mr. Compton's memory of the deficiencies of his timepiece in the Andes. Mr. Compton acknowledged the correctness of the calculation, and I shall not forget the expression of wonder on his face.

It is with such a man that we in the Institute could consult daily, and it is such a man that we have lost.

Let us pause a moment and ask ourselves why a man of this calibre abandoned a comfortable professorship and great honors in his own country to join us and become a citizen of the United States. Many other intellectuals of the highest type have done likewise. There is really only one reason, namely, that the limitations placed on the range and freedom of activity of the mind had become intolerable in the countries which they left. They could not tolerate politicians proclaiming and acting upon pseudo-racial doctrines that could not for a moment stand the light of rational analysis. They could not tolerate a climate in which responsible and vigorous criticism of political actions was rewarded with defamation of character and possibly with imprisonment and death. Let us be sure that our freedoms here in these respects remain unimpaired. As long as men like Enrico Fermi turn to us and join us, though hosts be against us, we shall prevail.

THE speakers on our program have been chosen because of long and intimate association with Mr. Fermi. Professor Emilio Segrè, who will speak first, was the recipient of the first Doctor of Philosophy degree awarded under Fermi's sponsorship at the University of Rome. He was one of the group who associated there with Mr. Fermi in his classic researches on the properties of slow neutrons. Professor Segrè comes from the Department of Physics of the University of California for this occasion.

The final speaker will be Professor H. L. Anderson, who is a member of the staff of our Institute for Nuclear Studies. He was a student of Mr. Fermi's at Columbia University, and worked continuously and closely with him during the great effort of the war years, which led to the controlled release of nuclear energy from uranium, twelve years ago yesterday, here on our campus.

A Tribute to Enrico Fermi by Emilio Segrè

WE are here to commemorate and honor one of the greatest scientists of the century and it is appropriate that the highlights of his achievements, some of which seem likely to become of transcendental importance for mankind, be properly mentioned. But the choice of speakers, not from his peers in science, but from pupils and friends, seems to me to indicate a desire to have his human traits remembered also.

However, for Enrico Fermi physics was almost synonymous with life, and the man and the scientist are one. Any effort to separate them would be futile and irreverent.

He was born in Rome on September 29, 1901, and hence his much too brief life spanned only 53 years. He studied at Rome, and at Pisa at the Scuola Normale, an institution stemming from Napoleonic times which gave many illustrious scientists to Italy.

He obtained his Doctor's degree in 1922 with a thesis on X-rays. However, he was essentially self-taught, or better, his real spiritual teachers were a strange assortment of books ranging from a natural philosophy of the Jesuit Father Caraffa, written in 1840, the *Mécanique Rationelle* of Poisson, to Kelvin and Tait, Richardson's *Theory of Electrons,* and, above all, Sommerfeld's *Atombau* for the more modern subjects. These he read between the end of childhood and the end of adolescence.

His first published works are concerned with relativity, mechanics, and electrodynamics. We see him trying his forces on several interesting subjects, but soon he moves to deep reflections on thermodynamics and statistical mechanics. Thus, he was all prepared to discover in 1926, immediately after the formulation of the exclusion principle by Pauli, the statistical laws followed by the antisymmetrical particles now called fermions.

This work brought him at once to a pre-eminent place among theoretical physicists, and it was promptly followed by numerous other studies in atomic physics. In all of his work of the time we find his personal scientific style already fully developed. Really brilliant ideas are developed with such apparent simplicity of theoretical means that the results seem to flow without effort. The theory of the Raman effect, of the hyperfine structure, of the intensity of the alkali doublets, of the pressure shift of spectral lines, of the latitude effect in cosmic rays, the concept of the virtual quanta accompanying a moving charge, the statistical atom and many more, bear testimony to the universality of his interests and to the power of his genius. He initiated many a line of thought which was to be pursued by a whole generation—and the mine is not yet fully exploited.

I first met Fermi at this time and I remember the experience shared later by others of beginning a conversation with him, which ended by his taking a piece of chalk and improvising on a blackboard a theory that needed only to be written up and published. The last time that I saw this was, alas, on February 11th of this year when I was telling him about some nuclear experiments in which I was involved.

In 1927 the school of Rome was also founded and I beg to be excused if I am too personal in my remem-

Laura and Enrico Fermi in the latter's study at the Institute for Nuclear Studies at the University of Chicago. A warmly human panorama of Fermi's life is to be found in *Atoms in the Family*, a biography written by Mrs. Fermi and published last October by the University of Chicago Press.

brances. Fermi's exceptional ability had been recognized, not without some struggle, by a professorship at Rome, a coveted position and quite exceptional for a man of only 26 years. However, he decided then that he needed some help, and some co-workers, and in very characteristic fashion proceeded to create them. He selected a small nucleus of young men, by his own criteria, and trained them in his own unorthodox way. I do not think he ever spoke of scientific ideals or that he used any moralizing words, but by force of example inspired in everybody such a burning devotion to science that I venture to say that for this group of young men between ages 20 and 25, with a leader of 27 or 28, science was the greatest passion, none excluded. And the Fermi influence of their scientific outlook was indelibly impressed and persisted even after they lost Fermi's mannerisms of speech and deep voice which they had unwittingly acquired in their daily common life.

In the early 30's more theoretical work followed. A reformulation of Dirac's theory of radiation led Fermi in the abstract paths of second quantization from which his rather practical mind at first recoiled. But his feeling changed after he had developed in 1933 what he considered a "practical" application, namely the theory of beta decay, one of the milestones of theoretical nuclear physics. With this he began his career as a nuclear physicist.

However, 1934 was to be the wonder year in which, without abandoning theory, he entered professionally into the experimental field. Indeed he had always, even from his childhood, dabbled a little in experiment and some of his work with Rasetti is quite first class, but the plan he had nurtured for some time of attacking experimentally some important problem concerning the nucleus materialized when news came of Curie-Joliot's discovery of artificial radioactivity. Fermi realized at once that neutrons would be more powerful projectiles than charged particles and tried them immediately; it

is characteristic of the man that he tried in order all available elements beginning with hydrogen, and did not give up when the first eight were unsuccessful. The ninth, fluorine, finally gave a positive result. It was also characteristic that he summoned his young pupils and friends, mostly busy with their own problems, to come, help, work hard, and share the conquests with him.

A series of startling discoveries followed. The letters to the *Ricerca Scientifica,* sent to many nuclear scientists as what we would call today "preprints", elicited great interest, and Rome became, for a short period, the capital of the nuclear world. Lord Rutherford in person congratulated the young experimentalist for his debut. If I remember correctly, "Not bad for a beginner", were his own words in a congratulatory letter that he wrote at the time to Fermi.

In rapid succession all the elements, including uranium, were bombarded, but God, for his own inscrutable ends, made everybody blind to the phenomenon of fission. Chance confronted us with the strange phenomena undergone by neutrons in passing through hydrogenous substances; Fermi's mind grasped what was going on in a couple of hours. Thus, slow neutrons were discovered and these first steps, by a logical development, led him to study the diffusion of neutrons.

It was at this time more than at any other that I saw the full application of one of Fermi's outstanding human, or I would almost be tempted to say superhuman, characteristics, namely his unbelievable physical and mental strength. We were working quite methodically from 8 in the morning to 1, followed by lunch, siesta, and then again from 3 to 8 in the evening; but the intensity of the work was such that this practically represented the limit of our forces—and we were not weaklings.

However, every morning at 8, Fermi came back with some piece of theory concerning the neutron, ready to test it experimentally and to change it according to the results of the work of the day. This performance puzzled us a little, even knowing with whom we were dealing, but we soon discovered that the miracle occurred between 4 A.M. and 8 A.M. because he had insomnia and had decided to lengthen his day's work. I wanted to mention this because this strength and indomitable vitality was one of his fundamental characteristics.

By this time, intolerant persecution was rampant in Germany. We had had as visitors, guests, and friends, many brilliant young colleagues from central Europe, attracted to Rome by Fermi. Bethe, Bloch, Placzek, Peierls, London, and several others stayed with us for a few months, an ominous warning of impending catastrophe, and when in 1938, Italy also was submerged, Fermi departed as had many others, for the New World.

The aging Sommerfeld from Germany commented in a moving letter, "Sic transit gloria mundi veteris" (Thus passes the glory of the old world), and added, "To the greater glory of the New World."

In 1939, the Power which had initiated this tremendous chain of events opened the eyes of man to fission and Fermi, who had just arrived at Columbia, started a new group of young people, and, using his mastership of the neutron, embarked on that trip which was to land him, 12 years ago almost to the day, in that new world so properly indicated in the historic message announcing the criticality of the pile. One of his companions in this trip will tell you about it.

I cannot terminate this brief tribute without mentioning some things which I find I have omitted, because in writing with Fermi in mind they just did not occur to me: he had had all the honors that a scientist can have, none excluded. He was part of great councils, and for a large group of scientists his word was final. I have not mentioned these facts because for him they were really unimportant. Nothing altered his simplicity, which did not arise from false modesty—indeed he knew quite well how much he was intellectually above other men—but from charity. Nothing altered his unceasing interest in Science and his will to work humbly and indefatigably on the study of nature. If he had foreseen the cruel destiny that was to deprive us of him so unexpectedly early, he could not have husbanded his time to give more than he gave.

A Tribute to Enrico Fermi by H. L. Anderson

TODAY we are gathered here to pay our respects and to honor Enrico Fermi. He was our friend, our colleague, and our teacher, and he was a great man.

When he came to America 16 years ago, Enrico Fermi was already a celebrated scientist. He had a long list of scientific achievements. He had discovered new and fundamental laws of nature. The Fermi-Dirac statistics, his theory of the beta rays and his statistical atomic model stand out among many other great accomplishments. For his mastery of the neutron he had been awarded the Nobel prize and he stood at the pinnacle of his profession.

But now the Fascist mold had begun to infect the free and fruitful development of science in Italy. Fermi, with characteristic courage and decision, turned his back on his native land and set out to America to establish the American branch of his family. In America, Fermi could expect to find fertile ground for his ideas and a receptive climate for his genius. For the sanctuary which we gave him then, Fermi repaid us a thousandfold. We can be forever grateful that, when he came to us, our gates were open.

His needs were few. Chalk, a blackboard, and an eager student or two were enough for a start. Teaching was an essential part of his method. Through teaching he would sharpen his wits, clarify his thoughts, develop his ideas. Students and colleagues soon learned that no one could touch him when it came to clarity and brilliance of lectures. It was usually "Standing Room Only" when Fermi spoke—but he would lecture with equal

brilliance to a lone student. And he would make a deal —if you would correct his English and teach him Americanisms—he would teach you physics.

The eternal scholar, Fermi was always eager to learn. He was always grateful when he found out something new. What he learned he felt he should enrich. Having enriched what he learned he felt he should teach it to others. Thus, he prepared the fertile ground out of which arose the new solutions and new ideas which kept his subject bright, fresh, and exciting.

At Columbia he had hardly settled his family when news of the discovery of the fission of uranium arrived. "Let me explain this business of the fission of uranium," he said. "The neutron enters and causes an instability in the uranium nucleus and it's split apart. A great deal of energy is released, as Otto Frisch has shown. But the circumstances are those in which, in all probability, neutrons will be emitted as well, and this is at the root of the matter. For if the neutrons are emitted in greater number than they are absorbed, a chain reaction will be possible and the way to a new source of energy will have been found. Come and help me find these neutrons. Let us measure their absorption and their emission with some care so that we can understand these processes in detail and know how to proceed."

To explore the mysteries of nature with Enrico Fermi was always a great adventure and a thrilling experience. He had a sure way of starting off in the right direction, of setting aside the irrelevancies, of seizing all the essentials and proceeding to the core of the matter. The whole process of wresting from nature her secrets was for Fermi an exciting sport which he entered into with supreme confidence and great zest.

No task was too menial if it sped him towards his goal. He thoroughly enjoyed the whole of the enterprise: the piling of the graphite bricks, the running with the short-lived activated rhodium foils, and the merry clicking of the Geiger counter which effected the measurement. All was done with great energy and obvious pleasure, but by the end of the day, in accordance with his plan, the results were neatly compiled, their significance assessed, and the progress measured, so that early in the morning on the following day, the next step could begin.

It was a feature of the Fermi approach never to waste time, to keep things as simple as possible, never to construct more elaborately or to measure with more care than was required by the task at hand. In such matters his judgment was unerring. In this way, step by step, the work sped forward until in less than four short years Fermi had reached his goal. A huge pile of graphite and uranium had arisen in the West Stands of the University of Chicago Campus. When, on December 2, 1942, 12 years ago just yesterday, Enrico Fermi stood before that silent monster he was its acknowledged master. Whatever he commanded it obeyed. When he called for it to come alive and pour forth its neutrons it responded with remarkable alacrity; and when at his command it quieted down again, it had become clear to all who watched that Fermi had indeed unlocked the door to the Atomic Age.

By now the Manhattan Project had grown enormously in size. The exigencies of war required it to produce atomic bombs and it assumed a character not at all in keeping with the Fermi style. Administrative and organizational responsibilities usually charged with controversy he avoided. But there were those who came to recognize that in scientific and technical matters the words of Fermi were golden. Such advice he gave generously and freely and so in unobtrusive ways he helped guide the whole enterprise to its successful conclusion.

There followed a period at Los Alamos where Fermi had been asked to go to participate more directly in the atomic bomb work. Here the work had been already well advanced by a group of distinguished scientists among whom were many former colleagues. They too, like himself, had found sanctuary in America from the oppressions of Europe. Here, in a remarkable cooperative effort, the atomic bomb was designed, made, and tested.

One unerasable picture of Fermi had to do with the fateful morning set aside to test the first atomic bomb. It showed Fermi standing in the blinding glare of that explosion, methodically dropping small bits of paper to the ground. Some of these were carried forward by the arrival of the blast. Impatient to know the strength of the atomic explosion, Fermi had devised his own simple means for measuring it.

What Fermi missed at Los Alamos was the University. This he regained at Chicago, whose faculty he joined at the end of the war. Here, in the Institute for Nuclear Studies, established essentially according to his own design, he was again free to explore nature according to his fancy. Students flocked to his classes while physics itself, flushed with its success on the field of battle, surged on in new directions.

New particles had been discovered and huge electronuclear machines had been constructed to produce them. Here, at Chicago, under his guidance, we built a huge synchrocyclotron. This became Enrico's newest plaything. This machine could produce the mesons which had come to occupy the center of the stage. These were the particles which were responsible for the nuclear force. A new great challenge for Enrico. What were the facts? What was their meaning?

Counters, liquid hydrogen, magnets, all the paraphernalia of modern physics were brought to bear with Enrico in the thick of it. It was in the midst of this work that from an unexpected quarter, Enrico Fermi was suddenly and unaccountably struck down.

We all know what a pleasure it was to have Enrico around; what a privilege it was to work with him. We all know how considerate and thoughtful he was; how helpful he could be. He was the center of our Institute around whom all revolved and for whom we all tried to do something good enough to win his praise. Well, he isn't going to be around any more. We're going to miss him awfully but we can all try to keep the spirit that he had.