The Lost Café

by Gian-Carlo Rota

One morning in 1946 in Los Angeles, Stan Ulam, a newly appointed professor at the University of Southern California, awoke to find himself unable to speak. A few hours later he underwent an emergency operation. His skull was sawed open and his brain tissue sprayed with newly discovered antibiotics. The diagnosis—encephalitis, an inflammation of the brain. After a short convalescence he managed to recover, apparently unscathed.

In time, however, some changes in his personality became obvious to those who knew him. Paul Stein, one of his collaborators at Los Alamos, remarked that, while before his operation Stan had been a meticulous dresser, a dandy of sorts, afterwards he became visibly careless in the details of his attire, even though his clothing was still expensively chosen.

When I met him, many years after the event, I could not help noticing that his trains of thought were unusual, even for a mathematician. In conversation he was livelier and wittier than anyone I had ever met, and his ideas, which he spouted out at odd intervals, were fascinating beyond anything I have witnessed before or since. However, he seemed to studiously avoid going into any details. He would dwell on a given subject no longer than a few minutes, then impatiently move on to something entirely unrelated.

Out of curiosity I asked Oxtoby, Stan's collaborator in the thirties, about their working habits before his operation. Surprisingly, Oxtoby described how at Harvard they would sit for hours on end, day after day, in front of the blackboard. Since I met him, Stan never did anything of the sort. He would perform a calculation, even the simplest, only when he had absolutely no other way out. I remember once watching him at the blackboard trying to solve a quadratic equation. He furrowed his brow in rapt absorption, while scribbling formulas in his tiny handwriting. When he finally got the answer, he turned around and said with relief, "I feel I have done my work for the day."

The Germans have aptly called *Sitzfleisch* the ability to spend endless hours at a desk doing gruesome work. *Sitzfleisch* is considered by mathematicians to be a better gauge of success than any of the attractive definitions of talent with which psychologists regale us from time to time. Stan Ulam was able to get by without any *Sitzfleisch* whatsoever. After his bout with encephalitis, he came to lean instead on his own unimpaired imagination for new ideas and on the *Sitzfleisch* of others for technical support. The beauty of his insights and the promise of his proposals kept him amply supplied with young collaborators always willing to lend (and sometimes risking to waste) their time.

A crippling technical weakness coupled with an extraordinarily creative imagination is the drama of Stan Ulam. Soon after I met him, I was made to understand that, as far as our conversations went, his drama would be a Forbidden Topic. Perhaps he discussed it with his daughter, Claire, the only person with whom he would occasionally have brutally frank discussions, but certainly not with anyone else. But he knew I knew, and I knew he knew I knew.

Stan Ulam was born into a family that stood as high on the social ladder as a Jewish family could at the time. He was the golden boy from one of the richest families of Lwów. In central Europe the Ulam name was then a synonym of banking wealth, not unlike the Rothschilds' in western Europe. He was educated by private tutors and in the best schools. As a child he already showed an unusual interest in astronomy ("I am star-struck," he would often tell me) and in physics. At the age of twelve he was reasonably familiar with the outlines of the special theory of relativity, a great novelty at the time. In high school he was a top student, far too bright for his age. His quick wit got him good grades with little effort but lent free rein to his laziness.

The two authors he read thoroughly in his teens were Karl May and Anatole France. They had a formative influ-

ence on his personality, and throughout his life he kept going back to them for comfort. From Karl May's numerous adventure novels (popular enough in the German-speaking world to be among the favorite books of both Einstein and Hitler) he derived the childlike and ever fresh feeling of wonder that is often found in great men. From Anatole France he took his man-of-the-world mannerisms, which in later life would endear him to young ladies.

He kept a complete set of Karl May's novels (in German, the other language of his childhood) behind his desk until he died. He regretted that a *Pléiade* edition of Anatole France had not been published, which he could keep by his bedside. He often gave me paperbacks of Anatole France, bought on his frequent trips to Paris and dedicated with inscriptions urging me to read them. I regret to admit I haven't.

There was never any doubt that he would study mathematics when, at age seventeen, he enrolled at Lwów Polytechnic Institute. Shortly after classes started he discovered with relief that the mathematics that really mattered was not taught in the classroom, but was instead to be found alive in one of the large cafés in town, the Scottish Café. There the Lwów mathematicians would congregate daily. Between a shot of brandy and a cup of coffee, they would pose (and often solve) what turned out to be some of the outstanding mathematical conjectures of their time, conjectures that would be dashed off on the marble of coffee tables in the late evenings, in loud and uninhibited brawls.

The Lwów school was made up of offbeat, undisciplined types. Stan's teacher Banach was an alcoholic, and his best friend Mazur was a Communist. They cultivated the new fields of measure theory, set theory, and functional analysis, which at the time required very little background. The rival Warsaw mathematicians, more conservative, looked down on the Lwów mathematicians as amateurish upstarts, but the results of the Lwów school soon came to be better known and appreciated the world over, largely after the publication of Banach's book on linear operators, in which Ulam's name is the most frequently mentioned.

One day the amateur Ulam went one up on the Warsaw mathematicans, who cultivated the equally new field of algebraic topology. While chatting at the Scottish Café with Borsuk, an outstanding Warsaw topologist, he saw in a flash the truth of what is now called the Borsuk-Ulam theorem. Borsuk had to commandeer all his technical resources to prove it. News of the result quickly swept across the ocean, and Ulam became an instant topologist.

Stan took to café-mathematics like a fish to water. He quickly became the most daring of the Lwów mathematicians in formulating bold new mathematical conjectures. Almost all his guesses of that time have been proved true and are now to be found as theorems scattered in graduate textbooks.

In the casual ambiance of the Scottish Café, Stan blossomed into one of the most promising mathematicians of his generation. He also began to display the contradictory traits in behavior that after his operation were to become dominant: deep intuition and impatience with detail, playful inventiveness and dislike of prolonged work. He began to view mathematics as a game, one that a well-bred gentleman should not take too seriously. His insights have opened whole new areas of mathematics, all of them still actively cultivated today, but he himself could not bear to give his discoveries more than a passing interest, and at times he would make merciless fun of those who did take them too seriously.

The papers in mathematics that he wrote by himself date back to this period. Most were written in one sitting, often in a night's work, probably in response to some colleague's challenge at the Scottish Café. Much of his present reputation as a mathematician rests on these short, brilliant notes. His measurable cardinals, the best idea he had in this period, are still the mainspring of much present work in set theory. More often, however, his flashes of originality, scattered as they are in unexpected contexts, have been appropriated by others with little acknowledgement, and have proved decisive in making more than one career in mathematics. For example, his paper with Łomnicki on the foundations of probability, which also dates back to his Polish period, contains a casual remark on the existence of prime ideals in Boolean algebras, later developed by Tarski and others in several formidable papers.

The Borsuk-Ulam theorem was striking enough to catch the attention of Solomon Lefschetz, the leading topologist of the time and the chairman of the Princeton mathematics department. Through Lefschetz and von Neumann, with whom he had started to correspond, Ulam was invited in 1936 to visit the Institute for Advanced Study in Princeton.

For four years he commuted between Poland and America where, first in Princeton and later at the Harvard Society of Fellows, he lived in luxury on his parents' monthly checks. In the summer of 1939, shortly after he returned to the United States with his brother from what would be the last visit to his family, World War II broke out. By accident he had been saved from almost certain extinction. He would never leave the United States again, except on short trips.

The *belle époque*, the period that runs between 1870 and the 1930s (though some claim that it ended with World War I), was one of the happiest times of our civilization. Vienna, Prague, Lwów, and Budapest were capitals of turn-of-the-century sophistication, though they lacked the staid traditions of Paris, Florence, or Aranjuez. Robert Musil, Gustav Mahler, Franz Kafka, Ludwig Wittgenstein, and the philosophers of the Vienna Circle have become for us symbols of *mitteleuropaische Kultur*. Most of those now legendary figures betrayed personality traits similar to Stan's: restlessness, intolerance, a dialectic of arrogance and contrition, and an unsatisfied need for affection, compounded by their society's failure to settle on a firm code for the expression of emotion. Perhaps the roots of the tragedy that befell central Europe should be looked for in those men's tragic lives and flawed personalities, rather than in the scurrilous outbursts of some demented housepainter.

When the catastrophe came, those among them who were still alive to watch their world go up in flames never recovered from the shock. They remained emotionally crippled for the rest of their lives.

Stan Ulam was one of them. Had he been able to remain in Poland and survive the war, as Steinhaus, Kuratowski, and a few others did, he would have gone on to become one of the leading international figures of pure mathematics, at least on a par with Banach. But after he bade farewell to his friends at the Scottish Café, something died forever within him, and his career as a pure mathematician went permanently adrift.

Like other immigrants from the European leisure class, Stan arrived in the United States ill-equipped for the rigors of puritan society.

The big open spaces of America, the demands for aloneness and self-reliance made him feel estranged. He wished to belong, and he loved this country, but he never came to feel fully at home in the United States, whether in Cambridge, Madison, or Los Alamos. He missed the lively street life of European cities, the culture, the rambling conversations (what the Spanish call *tertulias*) and viewed with alarm the decay of that art, which in our day has become all but extinct.

By now the effective American way of scientific exchange has imposed itself on the rest of the world. But fifty years ago life in American universities was incomparably duller than the café-science of Lwów. The atmosphere of Cambridge in the thirties was too cold, and, what was worse, there were no cafés. And then, in Europe, the war started.

In the fall of 1939, Stan would spend endless hours watching the Charles River from his room at Harvard, stupefied by the sudden turn of events that had changed his life and that of so many others. He learned of the fall of Poland, of the deportation of his family

to a concentration camp (his sister and uncles were killed in gas chambers), of the sacking of the great Ulam bank.

He was all alone now. His father's monthly checks had stopped, his Junior Fellowship would soon run out, and he would have to support his brother's college education at Brown. He pinned great hopes on his big paper on ergodic theory, which he had just finished writing with Oxtoby and which had been accepted for publication in *Annals of Mathematics*, the most prestigious mathematics journal. In the solitude of Adams House, he could not bring himself to finish a paper by himself, though his lectures on the theory of functions of several real variables were the most brilliant he ever delivered (some former students still cherish the notes they took of that course).

G. D. Birkhoff, the ranking Harvard mathematician and the absolute monarch of American mathematics, took a liking to Stan Ulam. Like other persons rumored to be anti-Semitic, he would occasionally feel the urge to shower his protective instincts on some good-looking young Jew. Ulam's sparkling manners were diametrically opposite to Birkhoff's hard-working, aggressive, touchy personality. Birkhoff tried to keep Ulam at Harvard, but his colleagues balked at the idea. After all, Ulam had only one long paper in course of publication, and it can be surmised that the Harvard mathematicians of the thirties turned up their noses at the abstract lucubrations of a student of Banach.

Birkhoff then began to write letters to his friends at several universities, suggesting Ulam's name for appointment. It didn't take long before Stan received an offer from the University of Wisconsin in Madison, an assistant professorship carrying a rather high stipend for the time, over two thousand dollars. He had no choice but to accept it.

For the first time in his life, Stan had to do "an honest day's work," and he didn't like the thought. The teaching load of some twelve hours a week of pre-calculus soon turned into a torture. Rumor had it that he had occasionally fallen asleep while lecturing. Madison, a friendly little Midwestern town, was the end of the world for a worldly young European. The ambiance was more non-existent than dismal. His colleagues, upright men and world-renowned mathematicians like Everett and Kleene, were not the garrulous Slavic types he was used to. Then after Stan's second year at Wisconsin, America entered the war.

Once more John von Neumann came to Stan's rescue.

Of all escapes from reality, mathematics is the most successful ever. It is a fantasy that becomes all the more addictive because it works back to improve the same reality we are trying to evade. All other escapes—love, drugs, hobbies, whatever—are ephemeral by comparison. The mathematician's feeling of triumph, as he forces the world to obey the laws his imagination has freely created, feeds on its own success. The world is permanently changed by the workings of his mind, and the certainty that his creations will endure renews his confidence as no other pursuit. The mathematician becomes totally committed, a monster like Nabokov's chess player, who eventually sees all life as subordinate to the game of chess.

Many of us remember the feeling of ecstasy we experienced when we first read von Neumann's series of papers on rings of operators in Hilbert space. It is a paradise from which no one will ever dislodge us (as Hilbert said of Cantor's set theory). But von Neumann's achievements went far beyond the reaches of pure mathematics. Together with Ulam he was the first to have a vision of the boundless possibilities of computing, and he had the resolve to gather the considerable intellectual and engineering resources that led to the construction of the first computer. No other mathematician of this century has had as deep and lasting an influence on the course of civilization.

Von Neumann was a lonely man with deep personal problems. He had two difficult marriages. He had trouble relating to others except on a strictly impersonal level. Whoever spoke to him noticed a certain aloofness, a distance that would never be bridged. He was always formally dressed in impeccable business suits, and he always kept his jacket on (even on horseback), as if to shield himself from the world.

Stan was probably the only close friend von Neumann ever had. A similar background and a common culture shock brought them together. They would spend hours on end gossiping and giggling, swapping Jewish jokes, and drifting in and out of mathematical talk.

Stan was the more original mathematician of the two, though he accomplished far less in mathematics than von Neumann did. Von Neumann had an incomparably stronger technique. From their free play of ideas came some of the great advances in applied mathematics of our day: the Monte Carlo method, mathematical experiments on the computer, cellular automata, simulated growth patterns.

Like everyone who works with abstractions, von Neumann needed constant reassurance against deep-seated

and recurring self-doubts. Following his uncanny instinct for doing the right thing at the right time, Stan soon found the way to cheer up his brooding friend. He began to make fun of von Neumann's accomplishments. He would mercilessly ridicule continuous geometries, Hilbert space, and rings of operators, cleverly picking on weaknesses in von Neumann's work that were obvious and expected. Stan's jibes were an indirect but firm expression of admiration. Rather than feel offended, von Neumann would burst out in a laughter of relief.

Much later, when Stan related to me these events, he affected to regret never having said a kind word to von Neumann about his work in pure mathematics. But I could feel he was not serious. Deep inside he knew he had been good to his friend.

Stan didn't fully realize how much von Neumann meant to him until his friend began to die of cancer, in 1955. Stan would make frequent trips to Walter Reed Hospital in Washington, where for months on end his honored friend was confined to a bed in the Presidential Suite. Stan came prepared with a bagful of the latest jokes and prurient Los Alamos gossip. The little hospital bed would shake with the vibrations of von Neumann's big belly as he laughed himself to tears, the very tears that Stan was fighting to control. Then weeks passed when von Neumann could no longer recognize anyone. When he finally died, Stan broke into tears. It was probably the only time in his life when he openly lost control of his emotions.

Back in 1941 shortly after the United States entered the war, Stan (then still at Wisconsin) began to notice that von Neumann's letters were becoming infrequent. Curious about his friend's mysterious unavailability, Stan managed one day to corner him in Chicago. He implored von Neumann to drag him out of his Wisconsin rut and to get him a job related to the war effort. The request fit perfectly with von Neumann's plans. He had already made up his mind to bring Stan with him to the newly founded Los Alamos laboratory, where the atomic bomb project was being launched.

The choice of a set theorist for work in applied physics might seem eccentric, but in retrospect von Neumann made the right choice. Besides, as the token mathematician in a sea of physicists (though he was probably one of the finest minds among them, together with Fermi and Feynman), von Neumann was relieved to have his cohort join him.

The assembly of geniuses who roamed the corridors of the Los Alamos laboratory during World War II has not been matched in recorded history, with the possible exception of ancient Greece. In the hothouse of the Manhattan Project, Stan's mind opened up as it hadn't since the days of the Scottish Café. The joint efforts of the best scientists of the time, their talents stimulated and strained by the challenge of a difficult project, made what could have been a drab weapons laboratory into a cradle of new ideas. In welcome breaks between long stints at the bench, in a corner at some loud drinking party, the postwar revolutions in science were being hatched.

Los Alamos was a turning point in Stan Ulam's career. From that time on physics, not mathematics, became the center of his interest. After watching Fermi and Feynman at the blackboard, he discovered that he too had a knack for accurately estimating physical quantities by doing simple calculations with orders of magnitude. In fact, he turned out to be better at that game than just about anyone around him.

It is hard to overstate how rare such an ability is in a mathematician. The literalness of mathematics is as far removed from the practical needs of the physicist as might be the story of the Wizard of Oz. As Stan began to display his newly found talent, he came to rely less and less on standard mathematical techniques and to view ordinary mathematics with some contempt. He admired Fermi's genius for solving physical problems with no more than the minimum amount of math. Since that time Fermi remained for him the ideal of a scientist. In his old age he liked to repeat (perhaps with a touch of exaggeration) that Fermi had been the last physicist.

But the Magic Mountain lasted only as long as the war. In 1945 it seemed that the Los Alamos laboratory might close down, like many other wartime projects, and Stan began to look for a job elsewhere. Unfortunately, his list of publications was hardly longer now than it had been in 1939, and unpublished work gets no credit. To his chagrin he was ignored by the major universities. He finally had to accept the offer of a professorship at the University of Southern California, at the time a second-rate institution but one with great plans for the future.

Suddenly he found himself in the middle of an asphalt jungle, teaching calculus to morons. The memories of his friends in Los Alamos, of the endless discussions, of the all-night poker games, haunted him as he commuted daily among the tawdry streets of Los Angeles. The golden boy had lost the company of great minds, his audience of admirers. Like anguish that could no longer be contained, encephalitis struck.

We still tend to regard disease as a mere physical occurrence, as an unfore-

seen impairment of the body that also, mysteriously, affects the mind. But this is an oversimplification. After a man's death, at the time of the final reckoning, an event that might once have appeared accidental is viewed as inevitable. Stan Ulam's attack of encephalitis was the culmination of his despair.

After recovering from his operation, Stan resigned his position in a hurry and went back to Los Alamos.

The year was 1946, and the Los Alamos laboratory was now a different place. Gone were most of the luminaries (though many of them would make cameo appearances as consultants), and the federal government was lavishing limitless funds on the laboratory. For a few years Los Alamos scientists found themselves coddled, secure and able to do or not do whatever they pleased, free to roam around the world in red-carpeted MATS flights (that is, until Americans decided to give up the Empire they had won).

Ulam came back to Los Alamos haunted by the fear that his illness might have irreparably damaged his brain. He knew his way of thinking had never been that of an ordinary mathematician, and now less than ever. He also feared that whatever was left of his talents might quickly fade. He decided the time had come to engage in some substantial project that would be a fair test of his abilities, and one with which his name might perhaps remain associated.

While at Wisconsin, Stan had met Everett. They had jointly written the first paper on the subject that is now called algebraic logic (a beautiful paper that has been plundered without acknowledgement). Everett, a seclusive and taciturn man, was richly endowed with the ability to compute. He was a good listener, and he suffered from a paranoid fear of being fired for wasting Lab time on research in pure mathematics. He was a perfect complement to Stan. After he had accepted Stan's invitation to come to Los Alamos, they joined forces on a long and successful collaboration.

As their first project they chose the theory of branching processes. They believed they were the first to discover the probabilistic interpretation of functional composition. (They had ignored all previous work, all the way back to Galton and Watson in the nineteenth century! Stan never had the patience to leaf through published research papers. He hated to learn from others what he thought he could invent by himself and often did). They rediscovered all that had been already done, and added at least as much of their own. Their results were drafted by Everett in three lengthy lab reports, which found substantial applications in the theory of neutron diffusion, an essential step in the understanding of nuclear reactions. These reports were never published, but they nevertheless had a decisive influence on the development of what is still a thriving branch of probability theory. The authors have received little acknowledgement for their work, perhaps as a spiteful punishment for their own neglect of the work of others.

Their second project was the hydrogen bomb.

Stan Ulam and Edward Teller had disliked each other from the moment they had met. Since the days of the Manhattan Project, Teller had been somewhat of a loner. His behavior put him outside the main-line Bethe-Fermi-Oppenheimer group, and not even his fellow Hungarian von Neumann felt at ease with him. This despite the fact that he distinguished himself from the first days of Los Alamos as one of the most brilliant applied physicists there.

Teller related with difficulty and diffidence to other scientists of his age. He felt more at ease either with young people or with celebrities, highly placed politicians, generals and admirals. His group (what eventually became the Lawrence Livermore Laboratory after he left Los Alamos in a huff) was highly disciplined, rank-conscious, and loyal. He would sagely guide his students and assistants to doing the best research work they were capable of, and he would reward his followers with top-rank positions in academic administration or in government.

Since the success of the first bomb, Teller had been obsessed by the idea of the "Super." Because of disagreements between him and Oppenheimer, his project had more than once been on the verge of being cancelled. Now, Stan Ulam was out to get him by proving that his plans for the new bomb would not work.

For about two years Everett and Ulam worked frantically in competition with Teller's group. They met every morning for several hours in a little office out of the way. Ulam would generate an endless stream of ideas and guesses, and Everett would check each one of them with feverish computations. In a few months' time Everett wore out several slide rules. At last they proved Teller wrong. And then, adding insult to injury, Stan, in a sudden flash of inspiration, came upon a trick to make the first hydrogen weapon work.

The full extent of Stan's contribution to the design of the first hydrogen bomb will never be precisely established. It is certain, however, that he was instrumental in demolishing misguided proposals that would have resulted in considerable waste of time and funds. It is all but certain that the seed idea that finally worked was his own. At any rate, the ensuing loud dispute with Teller over the priority of the invention brought him wide publicity. (The patent application for the device was jointly submitted by Teller and Ulam.) The Democrats soon saw their advantage in adopting Ulam as a bulwark against the Republicans, who had Teller on their side. He was invited to sit in on important Washington committees and later became a darling of the Kennedy era.

At last some of the glitter of his Polish youth had come back, if not in the form of tangible wealth, at least in the guise of public recognition.

The late forties and fifties were the high point of Stan Ulam's life. His personality thrived. His conversation, always lively, became all the more witty and engaging. The better part of his day was spent telling jokes and funny stories and inventing one interesting mathematical idea after another, like a wheel of fortune that never stopped. The joke was the literary form he most appreciated. He would come up with anecdotes, ideas, and stories on any subject of his acquaintance, however little his competence. He so liked to dominate a conversation that some of his colleagues began to take pains to avoid him. Now he had to win every argument. When he felt he was on the losing side, he would abruptly change the subject, but not before seeing the bottom of the other person's position and summarizing it with irritating accuracy. Considering how fast it all happened, it is remarkable how seldom he misunderstood. Mathematicians felt put down, and Ulam's ways alienated him from the guild. He retaliated by claiming not to be a "professional" mathematician and by going into rambling tirades against the myopia of much contemporary mathematics.

The free rein Ulam gave to his fantasy fed on one of his latent weaknesses—his wishful thinking. He became an artist at self-deception. He would go to great lengths to avoid facing the unpleasant realities of daily life. When anyone close to him became ill, he would seize on every straw to pretend that nothing was really wrong. When absolutely forced to face an unpleasant fact, he would drop into a chair and fall into a silent and wide-eyed panic.

His severest critics were those close to him who felt excluded from his private world, who stood outside the mighty fortress of mathematics. His daughter would browbeat him and cut him to pieces at regular intervals, incredulous of her father's achievements. He took her criticisms in silence, and was fond of quoting one of James Thurber's lovely generalizations: "Generals are afraid of their daughters."

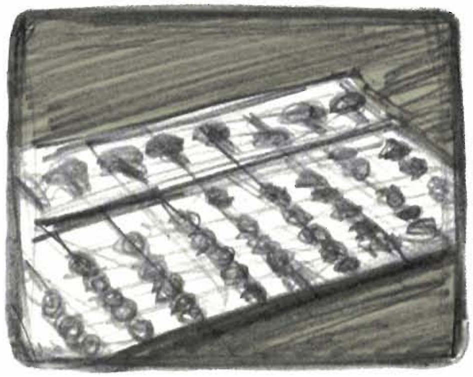
Despite the comfort of the Los Alamos Laboratory (in the fifties and sixties Ulam was one of two research advisors to the Director of the laboratory), Stan could find no peace there. Since his return in 1946, he had, unbelievable as it may sound, lived out of a suitcase. He owned beautiful homes in Los Alamos and Boulder, but he thought of himself as permanently on the road. (Significantly, his ashes are now in Montparnasse Cemetery in Paris.) The Scottish Café was gone forever, and he was a passenger on an imaginary ship, who survived on momentary thrills designed to get him through the day. He surrounded himself with traveling companions who were fun to be with and to talk to. He went to great lengths to avoid being alone. When he was, only the lure of mathematics could draw his mind away from the clamor of his memories.

I will always treasure the image of Stan Ulam sitting in his study in Santa Fe early in the morning, rapt in thought, scribbling formulas in drafts that would probably fill a couple of postage stamps.

The traits of Stan Ulam's personality that became dominant in his later years were laziness, generosity, considerateness, and most of all, depth of thought.

Those who knew Stan and did not know what to make of him covered up the mixture of envy and resentment they felt toward him by pronouncing him lazy. He was in fact lazy, in the dictionary sense of the word. In the thirties he would take a taxi to Harvard from his apartment in Boston to avoid tackling the petty decisions that a ride on the subway required. In Los Alamos there is a spot on a pathway up the Jémez Mountains that is called Ulam's Landing. It is as far as Stan ever went on a hike before turning back. More often, he would watch the hikers with binoculars from the porch of his house, while sipping gin and tonics and talking to his friends.

Like all words denoting human conditions, laziness, taken by itself, is neutral. It is a catchall that conceals a tension of opposites. *Fata ducunt, non trahunt.* Ulam turned his laziness into elegance in mathematics and into *grand seigneur* behavior in his life. He had to give all of his thinking an epigrammatic twist of elegant definitiveness. His failing became an imperious demand to get to



the heart of things with a minimum of jargon.

He had a number of abrupt conversation stoppers that he used to get rid of bores. One of them was a question designed to stop some long tirade: "What is this compared to $E = mc^2$?" When I first heard it (undoubtedly it was being used to stop me), I thought it a sign of conceit. But I was wrong. He would wake up in the middle of the night and compare his own work, too, to $E = mc^2$, and he developed ulcers from these worries. In truth, his apparent conceit was a way of concealing from others, and most of all from himself, the aging of his brain. On rare occasions he felt overwhelmed by guilt at his inability to concentrate, which he viewed as avoidance of "serious" work. He looked at me, his intense blue-green eyes popping and slightly twitching (they were the eyes of a prophet, like Madame Blavatsky's), his mask about to come down, and asked, "Isn't it true that I am a charlatan?" I proceeded to set his mind to rest by giving him, as a sedative, varied examples of flaming charlatans taken from scientists we both knew (both with and without Nobel Prizes). But soon his gnawing doubts would start all over again. He knew he would remain to the end a Yehudi Menuhin who never practiced.

His generosity was curiously linked to his laziness. A generous action is often impulsive and calls for little foresight. Its opposite requires the careful advance planning that Stan loathed. He fancied himself a *grand seigneur* of bottomless means, and in matters of money he was apt to practice the art of self-deception. In his penurious years he went to great lengths to conceal his shaky financial condition. He always lived as the spirit moved him, sometimes beyond his means. He carried on his person bundles of fifty and one-hundred dollar bills, partly from a remnant of the refugee mentality, partly to impress whomever he met during his travels.

He was also too much of a *grand seigneur* to insist on his priority for the many new ideas he contributed to science. His nonchalance as to the fate and success of his work has unjustly lowered his standing as a scientist. When he saw one of his ideas circulating without credit, he remarked, "Why should they remember me? No one quotes Newton or Einstein in the bibliographies of their papers."

His way of expressing himself lent itself to his being exploited. He would speak in sibylline pronouncements that seemed to make little sense. Those of his listeners who decided to pursue his proposals (and often ended up writing dozens of research papers on them) felt they had spent enough of an effort in figuring out what Stan really meant to reward themselves by claiming full credit.

A seed idea is the last thing we want to acknowledge, all the more so when it originates from a native intelligence seemingly blessed with inexhaustible luck. After we silently appropriate it, we will soon enough figure out a way to obliterate all memory of its source. In a last-ditch effort to salvage our pride, we will also manage to find fault with the person to whom we are indebted. Stan Ulam's weaknesses were all too apparent and made him more vulnerable than most. But the strength of his thinking more than made up for what he lost to the pettiness of others.

Stan once showed me in five minutes the central idea of the theory of continued fractions and thereby saved me much work. Once I bragged to him about some computations I had done on the speed of convergence in the central limit theorem, and he showed me how to derive the same result by an elegant argument with ordinary square roots.

Stan did his best work in fields where no one daréd to tread, where he would be sure of having the first shot, free from all fear of having been anticipated. He used to brag about being lucky. But the source of his luck was his boundless intellectual courage, which let him see an interesting possibility where everyone else could see only a blur.

He refused to write down some of his best ideas. He thought he would find some day the time and the help he needed to work them out. But he was misjudging the time he had left. His best problems will survive only if his students ever write them down.

Two of them have struck me. In the nineteenth century mathematicians could not conceive of a surface unless it was defined by specific equations. After a tortuous period of abstraction, the point-set topologists in this century arrived at the abstract notion of a topological space, which renders in precise terms our intuitive grasp of the notion of extension. Ulam proposed going through a similar process of refinement on Maxwell's equations to arrive at an abstract structure for electromagnetic theory free of algebraic irrelevancies.

The second problem bore on ergodic dynamical systems. Poincaré, and several others after him, taught us that in such a system every state is visited infinitely often, given a sufficiently long time. In practice, however, the recurrence times are so large that one cannot observe successive visits, and the practical import of ergodicity is nil. This paradox became strikingly evident after the Fermi-Pasta-Ulam computer simulations of coupled nonlinear oscillators. (These were written up in one of Fermi's last papers. It is rumored that Fermi considered this to have been his most important discovery.) In these nonlinear systems the initial state is visited several times before another set of available states is even approached. After observing this phenomenon, Ulam guessed that in some ergodic systems the phase space ought to be measure-theoretically represented by two or more big blobs connected by thin tubes. He wanted to express his guess in terms of ergodic theory. I wish we knew how.

Stan's fascination with physics led him to formulate mathematical thoughts that had a background of physics, but they invariably bore the unmistakable ring of mathematics. (He once started to draft a long paper that was to be titled "Physics for Mathematicians.") One of the most striking is his proposal for the reconstruction of the cgs system (distance, mass, and time) on the basis of a random walk. Another, which Dan Mauldin has recently proved true, is the existence of a limiting energy distribution for systems in which energy is redistributed through particle collisions.

Stan Ulam's best work is a game played in the farthest reaches of abstraction, where the cares of the world cannot intrude: in set theory, in measure theory, and in the foundations of mathematics. He used to refer to his volume of collected papers as a slim volume of poems. It is just that.

As a mathematician, his name is most likely to survive for his two problem books, which will remain bedside books for young mathematicians eager to make their mark by solving at least one of them. He also wanted to be remembered for those of his insights that found substantial practical applications, such as the Monte Carlo method, for which he will share the credit with Metropolis and von Neumann, and the bomb, for

which he will be remembered alongside Teller.

Only in the last years of his life did his thinking take a decisively speculative turn. He always professed to dislike philosophical discussions, and he excoriated ponderous treatises in philosophy. He thought them in bad taste, "Germanic" (one of his words of reprobation). Nonetheless, he had an instinctive grasp of philosophical issues, which he refused to express in words. When forced to take a philosophical stand, he would claim to agree with the naive scientism of H. G. Wells and with the positivism of the Vienna Circle (the reigning philosophy of his time), but in his actual thinking he was closer to the phenomenology of Husserl and Heidegger. His knowledge of philosophy suffered from his habit of scanning without reading. He seldom read a book from top to bottom; more often he would handle it long enough to pick out the main point, sometimes after correcting a few misprints, and then literally toss it away. I once set up a little test of his understanding of existentialism, by way of teasing him. I gave him a collection of poems written by Trakl, the first existential poet in German. Stan read them all and was visibly moved. I will always regret not being able to hold his attention long enough for him to get the basic idea of Husserl's phenomenology. He would have liked it.

Those of us who were close to him at the end of his life (Bednarek, Beyer, Everett, Mauldin, Metropolis, Mycielski, Stein, and I, to name a few) were drawn to him by a fascination that went beyond the glitter of new ideas of arresting beauty, beyond the trenchant remarks that laid bare the hidden weakness of some well-known theory, beyond the endless repertoire of amusing anecdotes. The fascination of Stan Ulam's personality rested in his supreme self-confidence. His self-confidence was not the complacency of success. It rested on the realization that the outcome of all undertakings, no matter how exalted, will be ultimate failure. From this unshakeable conviction he drew his strength.

This conviction of his, of course, was kept silent. What we heard from him instead were rambling tirades against mathematicians and scientists who took themselves too seriously. He would tear to shreds some of the physics that goes on today, which is nothing but poor man's mathematics, poorly learned and poorly dressed up in a phoney physical language. But his faith in a few men whom he considered great remained unshaken: Einstein, Fermi, Brouwer, President Truman.

Thinking back and recalling the ideas, insights, analogies, nuances of style that I drew from my association with him for twenty-one years, I am at a loss to tell where Ulam ends and where I really begin. Perhaps this is one way he chose to survive.

He could not bear to see unhappiness among his friends, and he went to any lengths to cheer us up when we were down. One day, we were driving towards the Jémez Mountains, along the stretch of straight road that starts right after the last site of the laboratory. I felt depressed, and drove silently, looking straight ahead. I could feel his almost physical discomfort at my unhappiness. He tried telling some funny stories, but they didn't work. After a minute of silence, he deployed another tactic. He

knew I had been interested in finding out just how much physics he really knew, and that I had unsuccessfully tried to quiz him. Now he launched on a description of the Planck distribution (which he knew I didn't know) and its role in statistical mechanics. I turned around, surprised at the thoroughness of his knowledge, and he smiled. But a few minutes later he again fell silent, and the gloom started all over. After a pause that was undoubtedly longer than he could bear, he blurted out: "You are not the best mathematician I have ever met, because von Neumann was a better one. You are not the best Italian I have ever met, because Fermi was a better one. But you are the best psychologist I have ever met." This time I smiled. It was his way of acknowledging our friendship. He knew that I could see through his weaknesses, through his laziness, through his inability to do any prolonged stint of work. He knew that I discounted those weaknesses, and that I saw, beyond them, the best of his person. That he appreciated.

No other period of civilization has been so dependent on hypocrisy for survival as the *belle époque*, the Victorian Age. It has bequeathed us a heritage of lies that we are now charged with erasing, like a huge national debt: the image of the hero as the fair-haired boy, and the sharp partition of all people into "good guys" and "bad guys." These false illusions must now make way for biographies in which ambiguity, duplicity, and the tension of opposites are seen as the fundamental forces that drive every person.

The prejudice that the scientist, as a seeker of the truth, is immune from the passions of the world and is capable of doing no wrong, a prejudice propagated for over a century by bigoted biographers, has done harm. One shudders to guess how many talented young minds have been discouraged from a career in science by reading such unrealistic portrayals of the scientist as a saint. Moreover the presumption that "good" behavior (as interpreted by the biographer) is a prerequisite for success in science betrays a lack of faith in science. Lastly, one should tell the truth, even when such a truth belies our ideas of how things ought to be.

Stan Ulam was lazy, he talked too much, he was hopelessly self-centered (though not egotistical), he had an overpowering personality. But he bequeathed us a view that bears the imprint of depth and elegance, one that enriches our lives and will enrich the lives of those who come after us. For this he will always be remembered. ■

Gian-Carlo Rota is a Professor of Applied Mathematics and Philosophy at the Massachusetts Institute of Technology. He has served as a consultant to the Laboratory for over twenty years.