Acclaim for George Johnson's

STRANGE BEAUTY

"If biography were diving, the brilliant and irascible Murray Gell-Mann (alive!) would have to be something like a reverse 3½ somersault half-twist from the pike position. George Johnson has nailed this one. *Strange Beauty* is complex, mind-expanding, beautiful, and true."
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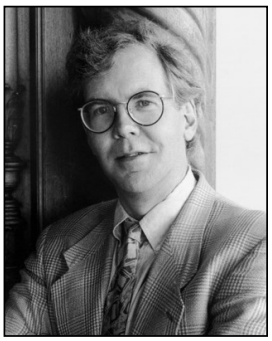

George Johnson

Strange Beauty

George Johnson is a former Alicia Patterson Fellow and finalist for the Rhône-Poulenc Prize. His work for *The New York Times* received the 1999 Science Journalism Award from the American Association for the Advancement of Science. His previous books include *Machinery of the Mind: Inside the New Science of Artificial Intelligence. In the Palaces of Memory: How We Build the Worlds Inside Our Heads,* and *Fire in the Mind: Science, Faith, and the Search for Order.* He lives with his wife in Santa Fe, New Mexico, and can be reached through the Web at talaya.net.

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STRANGE BEAUTY

Murray Gell-Mann and the Revolution in Twentieth-Century Physics

by GEORGE JOHNSON

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For Nancy

There is no excellent beauty that hath not some strangeness in the proportion.

—Francis Bacon
(Quoted by Murray Gell-Mann in an article explaining his theory of cosmic-ray particles whose behavior seemed to defy the laws of physics)

In our work we are always between Scylla and Charybdis; we may fail to abstract enough, and miss important physics, or we may abstract too much and end up with fictitious objects in our models turning into real monsters that devour us.

—Murray Gell-Mann, in a 1972 lecture on quarks in Schladming, Austria

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STRANGE BEAUTY

PROLOGUE

ON THE TRAIL TO LA VEGA

It was Memorial Day weekend of 1996, in the middle of what turned out to be one of New Mexico's worst droughts of the century. The seemingly endless dry spell reminded many of the climatic disaster said to have driven the Anasazi, the original inhabitants of this land, from their stone settlements around Mesa Verde, causing the collapse of a civilization. To escape the heat, I left my house in Santa Fe and drove as high as you can go into the nearby Sangre de Cristo Mountains. After leaving my Jeep in the ski basin parking lot, already some 10,000 feet above sea level, I began walking higher. My destination, La Vega, "the meadow," lay at the base of Santa Fe Baldy, an 12,600-foot peak of Precambrian granite that juts above the timberline.

Almost as soon as I reached the trail head, I realized that, once again, I had misjudged the perversity of New Mexico weather. Looking out across the Rio Grande Valley, I could see the next mountain range, the Jemez, where just weeks earlier a fire had devastated fifteen thousand acres of one of my favorite places, the wilderness backcountry of Bandelier National Monument. Now storm clouds were boiling up over the Jemez and sweeping toward the Sangre de Cristos. The temperature began dropping, and before long snow flurries, of all things, were swirling around me.

I was wishing I had worn a jacket and long pants instead of khaki shorts and a T-shirt, when, as I rounded a corner on the trail, I heard a familiar voice. "Well, hello," a man in a floppy cotton hat and a windbreaker called out enthusiastically. He was walking toward me from the opposite direction. "How are *you*?" he said. It took me a few seconds to realize that I had randomly encountered the subject of this biography, my Santa Fe neighbor Murray Gell-Mann, hiking with his stepson, Nick Levis.

For weeks now I had been trying to pin down Gell-Mann for another interview. He had been running hot and cold ever since I had told him, two years earlier, that I intended to write his life story. Lately he had been more helpful. But now I was worrying that his second thoughts were being followed by third and fourth thoughts, and I had no idea what stage our relationship was in. I was relieved that he seemed genuinely pleased to see me. And I was struck again by how much, contrary to so many of the legends, Gell-Mann liked people and conversation, the easy camaraderie of encountering someone familiar on a mountain trail. The physics lore is filled with stories of Gell-Mann cutting down a colleague with a withering remark, of the mocking names he assigned to people whose ideas he didn't respect. Particle physics is the most competitive of intellectual sports, and faced with a theory or a theorist he didn't like, Gell-Mann could be merciless. But up in the mountains, in New Mexico, he seemed almost able to relax.

He introduced me to Nick, who like me was shivering without a jacket. When I said I was headed for La Vega, Gell-Mann was delighted at the coincidence. "La Vega," he said, his mouth stretched wide to mimic as perfect a northern New Mexican accent as you might hear in the villages of Chimayo or Truchas, down the other side of the mountain. He and Nick had also been heading to La Vega when the drop in temperature caused them to turn around, a little way up the trail, at Nambe Creek—"*Nam*-be," Murray said, with just the right amount of padding around the *b*. Now they were heading home.

If Gell-Mann was disappointed about not reaching this particular goal, he didn't show it. His eyes sparkled, and he seemed happy just to be out in the woods again. A few weeks earlier, the cardiologists had stuck a catheter in his chest, checking on his progress since a recent heart attack. They were relieved to find that the artery they had scraped out—a Roto-rooting, Gell-Mann called it—was still open. There was another, less threatening obstruction further downstream, but the doctors decided to leave it alone.

I was tempted to turn around and join Murray and Nick on the hike back. But somehow it seemed improper. This was not Murray Gell-Mann, the Nobel laureate, the discoverer of the quark and the Eightfold Way, but simply a man on a holiday with his stepson. My strategy all along had been to avoid making him feel cramped. I was in this for the long haul. After a few minutes, we parted ways. I made it about a mile past Nambe Creek. Then, just before the

descent into the meadow, the clouds went black and I also decided to save La Vega for another day. Heading back down the mountain, I thought about how much I had come to like this brilliant, complicated, always fascinating, and often exasperating man.

When we visit the ruins of ancient civilizations, we reserve a peculiar fascination for those giant, elaborate structures that seem to serve no practical purpose whatsoever: the pyramids built by the Egyptians on the Nile and the Maya in Mexico, or the large circular kivas of Chaco Canyon in northwestern New Mexico. They stand meaningless now, rock-solid projections long outlasting whatever ideas they were meant to represent. Catholicism still survives, so we can understand some of the rationale behind Chartres, St. Peter's, and the other great cathedrals and basilicas of Europe. But we have barely a hint of the ideas that motivated the construction of the Sphinx.

It is sometimes said that the cathedrals of the late twentieth century are the giant particle accelerators, monuments to the belief—far from obvious on its face—that buried beneath the rough surface of the world we inhabit is a crystalline order so beautiful and subtle the mind can barely grasp it. Engaging in a fantasy, we can imagine, centuries and centuries from now, archaeologists (from this planet or perhaps from beyond the solar system) perplexed and captivated by the remains of the seventeen-mile-circumference particle accelerator being constructed at CERN, the European Center for Nuclear Research, near Geneva, or the four-mile ring at Fermilab in Illinois. These "atom smashers" are among the largest, most powerful machines ever built by the human race—not for the purpose of generating power, like the dams and nuclear reactors, or for predicting the weather or simulating nuclear explosions, like the supercomputers. Their sole purpose is intellectual: to find the faintest glimmers of evidence that, despite so many appearances to the contrary, we live in a mathematically symmetrical universe. How is it that a civilization long ago became so obsessed with this idea? That will be the riddle of these twentieth-century sphinxes.

If our parchments and our data banks survive along with the wreckage of our great machines, the archaeologists will learn a remarkable story: How the elders of the church of science came to believe that, despite what we perceive, matter is not continuous; it is made of invisible particles linked together in a beautiful architecture.

As the atomists would show over the years, the seemingly infinite variety of the world is generated by some one hundred elements, neatly arranged in the Russian chemist Dmitri Mendeleev's periodic table of the elements.

Viewed from the heavens, any hint of geometry on the earth—land divided into rectangles and circles, rock cut into blocks and piled straight and high—is usually a sign of intelligent creatures imposing order on an irregular world. But surely, the scientists believed, this harmony we find so soothing runs deeper. Beneath the world's confusion of forms is a scaffolding built according to a geometry as pleasing to the mind as a Gothic cathedral.

Since no one could directly see this geometry, the best one could hope for was to study its shadows. And so the physicists began to build the machinery they believed would provide an indirect glimpse. At first these devices were as simple as a jar enclosing gold foil leaves that seemed to waft in the wind of an invisible essence called electricity. By the early twentieth century, scientists were making gas-filled tubes that glowed in the dark with what they took to be mysterious beams of positive and negative charge. By studying and measuring these weird emanations, the physicists reached a powerful consensus: The world was even more elegant and symmetrical than Mendeleev and the atomists dared imagine. The variety of atoms found on the earth and in the sky were made up of combinations of just three particles: the proton, the electron, and the neutron.

But this newfound simplicity was short-lived. Not content with their instruments, the scientists built bigger and bigger machines. With the first particle accelerators, small enough to fit on a tabletop, they began smashing their elementary particles into each other and discovered that they weren't so elementary after all. They could be shattered into fragments. When they built bigger accelerators to smash the pieces even harder, they were left with fragments of fragments. Placing carefully designed detectors on mountaintops or sending them aloft in balloons, they found traces of still other particles, the cosmic rays bombarding the planet from space. Soon, there were so many of these "elementary" constituents that they threatened the very desire for order that had driven the search. The physicists were in despair.

And then, leading them out of the confusion, came the young scientists whose string of discoveries would do so much to make sense of it all, to find pattern hiding beneath the confusion. Viewed

through these magicians' wonderful new lenses, the clouds lifted and order shone through. But it came at a curious price. To restore beauty to the core of creation, humanity was asked to believe in truths stranger than any that had come before.

The most remarkable of these wizards was Murray Gell-Mann. Graduating from Yale University at age eighteen, by the time he was twenty-one he had earned a Ph.D. from the Massachusetts Institute of Technology. Less than three years later, he began his revolution with an astonishing theory explaining the unlikely behavior of certain cosmic rays—the so-called "strange particles" that bombarded the earth from space. The legend was born. From then until a decade later, when he proposed the existence of quarks, Gell-Mann dominated particle physics. He is sometimes called the Mendeleev of the twentieth century, for what he provided was no less than a periodic table of the subatomic particles. In a fanciful allusion to Buddhist philosophy, Gell-Mann called his organizing scheme the Eightfold Way. While the periodic table shows that the plenitude of atoms can be generated by combining just three particles—the proton, electron, and neutron—the Eightfold Way shows that the hundreds of subatomic particles are made up of a handful of the elements Gell-Mann named quarks. Complexity was reduced to simplicity again.

But there is an important difference between the architecture of Mendeleev and the architecture of the Eightfold Way. And it is here that one can glimpse the enormity of the intellectual upheaval brought on by Gell-Mann and his colleagues. The periodic table, now a commonplace in any high school chemistry course, classifies the elements according to properties we can perceive with our senses. Every element is characterized by a unique mass and charge. Mass is something we feel when we pick up a rock; we generate charge when we shuffle across a carpet and touch a doorknob. Classified according to these commonsense qualities, the elements miraculously arrange themselves into columns—the rare earth metals, the noble gases, and so forth—whose members share similar characteristics.

In its ability to sift pattern from chaos, the Eightfold Way is at least as powerful, but tantalizingly more subtle. The qualities Gell-Mann used to arrange the subatomic particles were far more abstract than charge and mass. In his scheme, particles were classified according to elusive qualities called isospin and strangeness, which have no counterpart in the world of everyday experience. To

describe the invisible patterns said to underlie the material world, Gell-Mann's strangeness was soon followed by more new qualities with names like charm, truth, and beauty. They "exist" not within the familiar world of three dimensions (four, if you include time), but within artificially constructed mathematical spaces, imaginary realms of pure abstraction.

Was this world stuff or mind stuff? To say that Gell-Mann "discovered" the quark is not quite right. All of his great breakthroughs came from playing with symbols on paper and chalkboards. His most important tools, he liked to say, were pencil, paper, and wastebasket. His discoveries were not of things but of patterns—mathematical symmetries that seemed to reflect, in some ultimately mysterious way, the manner in which subatomic particles behaved. But then "*invented* the quark" is not quite right either—implying some kind of postmodern relativism in which science is pure construction, just another philosophy. When Mendeleev drew his table, he left blank spaces for unknown elements that were discovered only years later. This manmade artifice was predicting truths about the real world. And so it was with the Eightfold Way. New kinds of particles demanded by Gell-Mann's abstract invention showed up in the experimenters' atom smashers.

The conflicting views of the nature of scientific ideas—are they discovered or invented?—are starkly laid out in the titles of two books: *The Hunting of the Quark* by Michael Riordan and *Constructing Quarks* by Andrew Pickering. Are quarks real particles (whatever that means) or mathematical contrivances? It's a debate that Gell-Mann refused to engage in. Philosophy, he thought, was a waste of time. But the puzzling questions about the reality of quarks—particles that cannot in principle be independently observed—quietly churned in his mind. One can see the struggle in the words he wrote and the lectures he gave. Ultimately he and just about everyone stopped worrying about it. Whether invented or discovered or something in between, it was Gell-Mann's quarks and his Eightfold Way that laid the foundation for the explanation physicists have given for how the world is made. For years particle physicists argued over who was the smartest person in their field: Richard Feynman or Murray Gell-Mann.

This idea of breaking the world into pieces and then explaining the pieces in terms of smaller pieces is called reductionism. It would be perfectly justified to consider Gell-Mann, the father of the quark, to be the century's arch-reductionist. But very early on, long

before mushy notions of holism became trendy, Gell-Mann appreciated an important truth: While you can reduce downward, that doesn't automatically mean you can explain upward. People can be divided into cells, cells into molecules, molecules into atoms, atoms into electrons and nuclei, nuclei into subatomic particles, and those into still tinier things called quarks. But, true as that may be, there is nothing written in the laws of subatomic physics that can be used to explain higher-level phenomena like human behavior. There is no way that one can start with quarks and predict that cellular life would emerge and evolve over the eons to produce physicists. Reducing downward is vastly easier than explaining upward—a truth that bears repeating.

In the last decade, what aspires to be a new branch of science has sprung up to try and come to grips with complex phenomena—organisms, economies, ecosystems, societies, the thunderstorms that sweep through the Rockies. Gell-Mann, some fifteen years after winning a Nobel Prize for his reductionist tour de force, reversed direction and helped found the Santa Fe Institute, a world center for studying complexity. Part of his motivation was political. An ardent conservationist, he hoped to find scientific ammunition to support his environmental causes. He wanted to understand the complexity of the rain forests and convince the world that they must be preserved. But he also hoped to deepen the world's understanding of the relationship between the unseen particles science understood so well and the unruliness of the world that confronts us every day. Sitting in his small office, with its pictures of the particles he had discovered hanging on the walls like family portraits, he would look out at the Sangre de Cristo Mountains, at all this rich biology and geology begging to be understood. And, though some of his Santa Fe colleagues would beg to differ, he believed he had come close to figuring it out.

For all his accomplishments, Gell-Mann hadn't always, or often, been as self-assured and easygoing as he appeared that afternoon hiking in the mountains. I shouldn't be fooled, some of his old colleagues told me, by the newer, mellower Murray. As I explored his past, I found that his reputation as an intellectual show-off was well earned. He had long been interested in almost everything—classical history, archaeology, linguistics, wildlife ecology, ornithology, numismatics, French and Chinese cuisine—and he was always

ready to lure people into conversations where he could display the depth of his knowledge and, it sometimes seemed, the shallowness of their own. The breadth of his learning had become legendary. He had taken visitors to dinner at Chinese restaurants, ordering in what seemed like passable Mandarin. He had strolled the streets of Kathmandu and Chinatown, translating the signs out loud. These performances could be exhilarating, and it was hard for people not to succumb to the pure delight he took as he reveled in the linguistic diversity of the world. But in his worst moments he could come off as a bully, someone who assumed that anyone who disagreed with him simply hadn't understood the argument. Everyone who knew him had seen the classic pose: Say something wrong or ask an ignorant question and he would raise his eyebrows in mock astonishment, then groan, holding hand to wrinkled brow as if his head were about to explode from the sheer weight of your misapprehension. He would sigh wearily, contemplating the effort he was about to expend setting you straight.

Over the years colleagues had been left dumbfounded by how self-centered the man could be. After accepting an invitation from the eminent journal *Nature* to speak at the most important event in its existence, the centenary celebration in London in 1969, Gell-Mann had abruptly canceled with three days' notice. He had an earache, he said. (As it turned out, the lecture was scheduled for the day after he would receive the early-morning call notifying him that he had won the Nobel Prize in physics—a coincidence, he would later insist; he hadn't been tipped off that the call was coming. And he really did have an earache, he pleaded to *Nature*'s editor, John Maddox, though, in the end, not a serious one.)

After charming his hosts by speaking in Swedish at the elegant Nobel Prize dinner, Gell-Mann had puzzled and then profoundly offended them by failing to submit his official lecture for publication in the annual celebratory volume. Seized with a pernicious case of writer's block, something that has plagued him all his life, he fended off one urgent telegram after another with abject apologies, finally conceding—months after the deadline was extended again and again for his benefit—that he wouldn't be submitting a lecture after all. Among the rows of volumes commemorating each year's prizes, one will find an empty page for Murray Gell-Mann.

It was difficult to know what to make of his behavior. He always seemed to feel genuinely sorry when he let people down. And it was hard for them not to forgive him, especially those who had seen his

other side. This was also a man capable of taking time from his research to write a long reply to a high school student seeking advice about a career in physics, or to a mother worrying over how to raise her young prodigy to be as emotionally solid as he was intellectually precocious. (It was a balance Gell-Mann regretted he had never himself achieved.) And for every physicist he had cut down, there was another whose career he had promoted. When it came to writing recommendations for students and colleagues, no one was more generous. When two younger physicists, George Sudarshan and George Zweig, received only scant recognition for independently discovering some of the same phenomena that led to Gell-Mann's fame, he tried to make amends, providing glowing testimonials, nominating them for awards. Sudarshan, he wrote, apparently came up with the long-sought theory of the weak nuclear force, which drives many forms of radioactive decay, before anyone else, including Gell-Mann and Feynman. Proposing Zweig for the prestigious Majorana Prize in physics, for "seminal work" on the quark model, Gell-Mann added, "his contributions to this go far beyond mine." But he didn't always follow through on his good intentions. When an editorial in the *New York Times* erroneously referred to the Israeli physicist Yuval Ne'eman, not Zweig, as co-discoverer of the quark, Gell-Mann made a note to write to the editor and set things straight. But he never got around to it.

He always felt overwhelmed by all the things he wanted, or was expected, to do. And he was terrible at organizing his time. Every day, he would sheepishly tell people, he fell eight years behind. As the years went by, he became a worse and worse correspondent. "I'm getting to be as bad as Dick Feynman at answering letters," he apologized to a colleague in 1960. Feynman had long been the standard by which one measured such things. Eventually, Gell-Mann stopped answering mail at all. The advent of e-mail only made matters worse. One day I walked into his office and found him sadly staring at the screen of his Powerbook, crushed by the sheer glut of electronic epistles to process. Each hitting of the delete key was a decision he would rather not have to make.

In Santa Fe, where he had moved after retiring from Caltech, both sides of the old Murray remained. The charming conversationalist and apologetic procrastinator alternated with the unrepentant dispenser of acid remarks. And as in the past, he was sometimes subject to volcanic eruptions. A new secretary at the Santa Fe Institute once made the mistake of mentioning that she

had just seen a television show about Feynman, who, since his death, had become such a celebrity. Murray erupted, attacking his old colleague's reputation and leaving her stupefied and wondering what she had done wrong. If Murray had mellowed from his days as the enfant terrible of physics, then the distinction was lost on her. He seemed to miss Feynman sometimes—he had once considered him among his closest friends—but he resented the way he had become enshrined like a dead rock star, with tapes of every lecture he had ever recorded dragged out of a closet somewhere and sold on cassette tapes and CDs to adoring fans.

Gell-Mann could be especially short with science writers, as I learned when I first met him, in 1992, at a conference on complexity in Santa Fe. The meeting was held at Sol y Sombra, the magnificent estate (the name means "sun and shade") on Old Santa Fe Trail where the artist Georgia O'Keeffe had gone to die. I walked into the meeting and got my first glimpse of Gell-Mann: his full head of tightly packed white hair, his styleless glasses with black plastic frames. He was wearing a bolo tie with a turquoise clasp and a jacket with an emblem of the Nature Conservancy, one of the environmental organizations he champions. The field of complexity is intimately related to the phenomenon called chaos, and Murray was loudly complaining about a popular book on the subject written by my former *New York Times* colleague James Gleick. I had admired *Chaos* immensely and was a little shocked when Murray denounced "this Gleick person," as he called him, for supposedly undermining the public's understanding of science. He conceded that Jim's book was beautifully written, but that somehow just made it worse. And Gleick's biography of Feynman made Murray livid. (Later he met Jim's brother, a scientist then visiting Santa Fe. They hit it off well, and from then on, Murray called him "the good Gleick.")

When the meeting broke for lunch, I carried my plate to one of the long wooden tables and sat down. I felt a mild adrenaline jolt when I saw Gell-Mann walk in my direction and, quite by accident, sit down across from me. He put out his hand and said in his deep, nasal voice, "Hi. I'm Murray Gell-Mann." I apprehensively introduced myself as an editor for the *New York Times*. "Oh, the *Times,*" he said, smiling with amusement. "That's the place that employs that—what is his name?—that *Wilford* person."

It seems that John Noble Wilford, the dean of American science journalism, had once written a story that Gell-Mann didn't like. In the mid-1980s, some scientists at Purdue University were arguing

that Galileo had got it wrong: A feather and a brick dropped inside a vacuum would not land simultaneously after all. A fifth force of nature—beyond gravity, electromagnetism, and the strong and weak nuclear forces—would cause some objects to accelerate faster than others. Wilford had called Gell-Mann to ask his opinion of what might conceivably have been a monumental discovery. After subjecting Wilford to a five-to-ten-minute oration on everything that was wrong with science-writing today, Gell-Mann tried to dissuade him from writing the piece. No one had heard of these scientists, Murray told him. Their analysis was shaky and would doubtless turn out wrong. As I listened to Gell-Mann tell the story, I could empathize with the frustration Wilford must have felt. Right or wrong, the fact that some card-carrying physicists were publishing this theory—now long forgotten—in *Physical Review Letters* was certainly newsworthy. Getting a quote from Gell-Mann would help put the story in perspective. I could imagine the clock ticking above Wilford's head, the deadline approaching, and Gell-Mann stubbornly refusing to cooperate. Looking for a good quote, Wilford apparently did what any of us might have done: He asked a leading question, something like, "Well, if the theory *does* turn out to be right, would it be important?" "Well, yeah, of course," Murray had replied. He was appalled to read the next morning on the front page of the *Times* that "Dr. Murray Gell-Mann, a theoretical physicist at the California Institute of Technology, said that if the conclusions of the study were correct, it was fair to speculate on the existence of a fifth force. . . ." Never mind that Wilford had taken all the care in the world to point out in his story how very tentative the research was. This had happened six years before, and Gell-Mann was not about to forgive him.

The story, given just the right spin by Gell-Mann, set off a round of laughter at the lunch table, which had filled with other physicists. I could see that it was going to be open season on science writers. And Gell-Mann was on a roll. "Things used to be worse," he said. He told about another science writer, a two-time winner of the Pulitzer Prize, who infuriated him by refusing to believe in the existence of the famously elusive particle called the neutrino. He was, Gell-Mann declared, "a man of impenetrable stupidity unmatched even by science writers today." This was getting to be a bit much. I had heard that Gell-Mann, the perfectionist and procrastinator, was having a huge amount of difficulty trying to write his own book, *The Quark and the Jaguar,* explaining complexity to a general audience.

The manuscript was late, and the publisher was ready to demand that he return his rather considerable advance. I couldn't resist. "How is your book coming along?" I asked. "Umm. Not very well," he admitted. He turned away and began talking to some physicists about string theory.

On the last day of the conference, when each scientist was giving a summary statement, I was asked (to my surprise and dismay) to tell what I thought of the affair. I had no idea what to say, but my encounter with Gell-Mann had been gnawing at me and I found myself describing our conversation at lunch that first day. The audience laughed at what they recognized as vintage Gell-Mann. And Murray stared straight ahead with a pained expression on his face. Sure that I had made an enemy, I avoided him for weeks. Then, at a Halloween party at one of his former student's houses (we were carving jack-o'-lanterns), he sat down next to me, as cordial as could be. "You know, I'm finding that this book-writing business isn't as easy as it looks," he said a little sheepishly. I took it as a touching concession, and before I knew it he was giving me chapters of his manuscript to read.

Though we had become friendly, he wasn't exactly thrilled when I told him two years later that I had decided to write his biography. He was a little flattered, I think, and he flattered me by saying I was one journalist he would trust to tell his story. But he wasn't sure he would be able to cooperate. His agent, John Brockman, was hoping to follow *The Quark and the Jaguar,* which had been sold to a dozen publishers around the world for more than a million dollars, with the *auto*biography of Murray Gell-Mann. He tried to convince Murray that this was a zero-sum game: Any good stories Gell-Mann told me would be money down the drain, material he couldn't use in his memoirs. I shouldn't have been surprised when, back in Manhattan, Brockman invited me for lunch in his office. Gell-Mann would tell all his friends and colleagues not to talk to me, he warned. I said I didn't believe for a minute that Gell-Mann had that kind of influence (he had made his share of enemies along the way). The agent struck again from a different direction. A biography about Gell-Mann written by a journalist is probably worth $100,000, he told me. But an autobiography—*coauthored* perhaps with a journalist—would be worth a million. But then it wouldn't be my book, I said. I had no intention of being amanuensis even for someone as intriguing as Gell-Mann. Though there are exceptions, the most honest biographies are usually unauthorized ones.

A little shaken (I had already signed a contract), I convinced myself I could write Gell-Mann's life story even if he refused to talk to me ever again. After all, the subjects of most biographies are dead. I started interviewing people Gell-Mann knew and struggling through the papers he had written. When he heard that I was planning a trip to Caltech, he called ahead to ask his colleagues not to tell me any "funny stories" about him. His agent had convinced him there was a market for a book of Gell-Mann anecdotes, like Feynman's *"Surely You're Joking, Mr. Feynman!"* a surprise best-seller. "I don't know any *funny* stories about Murray," one of his former collaborators grumbled, and proceeded to give me an earful of anecdotes Murray wouldn't have been tempted to put in his own book.

Soon after that, I moved from Manhattan to Santa Fe, where I would see Gell-Mann at scientific conferences or driving around town in a gold Range Rover with a license plate that read QUARKS. I would occasionally encounter him at restaurants and parties. Once my wife ran into him shopping alone at the Albertson's supermarket. (It was his turn to buy the groceries, he told her.) Slowly, I became a familiar presence and not so much of a threat.

Often we would see him with his wife, Marcia, a lovely poet he had met several years earlier in Aspen, Colorado, where he owned an old Victorian house. Gell-Mann was part of a group of physicists who had started going there in the 1960s for summer gatherings at the Aspen Center for Physics. Some of them, like Murray, had stretched a little and used their extra income from government and corporate consulting to buy homes for prices that seemed extravagant then—$100,000 for something that might cost $20,000 in the real world. Now they were real estate millionaires. Who would have guessed that particle physics would turn out to be so profitable, at least for some members of the generation that flourished after World War II?

Murray had been alone for a decade since his first wife, Margaret, the light of his life, died of cancer in 1981. Marcia had saved him, and Murray wanted her to know it. Only the biggest diamond earrings, the finest restaurants, the most expensive bottles of wine, were good enough. She drove around town in her own Land Rover. Sometimes the age difference—two decades—grated. He would complain about the loud rock music she liked to play or the parties she would organize with students from the writing class she taught at the University of New Mexico. It became a standing joke, Murray affectionately complaining about his "expensive wife." You could

hear the anxiety in his voice as well as the pride. With houses in Aspen, Santa Fe, and, for a while, Pasadena, it was taking a huge cash flow to sustain his existence. He always seemed to be off on another expensive adventure, traveling to South America, Mexico, Antarctica, Cuba, the Galápagos, driven to where he could see the most exotic birds, the most beautiful wildlife. And to help pay for the trips and the other expenses, he was hitting the lecture circuit, always on the run.

Whenever our paths crossed in Santa Fe, he was unfailingly friendly but still not quite convinced he should talk to me. I didn't press but let him know that I was quietly working away. But he hinted that his plans of writing a memoir were fading. He had so little time and writing was such agony for him.

Finally, a year after I had begun immersing myself in his life, he sat down for what would become a series of regular interviews. And toward the end of the project, he surprised me by allowing unrestricted access to his personal archives. One by one, he let go of his valuable anecdotes. One evening, early on, we went to dinner at a Chinese restaurant, one where Gell-Mann could get the low-fat food Marcia and his doctor had insisted on since the heart attack. Then we got in the Range Rover and drove up a winding dirt road—so rutted we had to slow to five miles per hour—to a place he owned in the foothills above Tesuque, a rural (or now semirural) community just north of Santa Fe. He was about to leave on a trip abroad and he needed to find his field glasses for bird-watching. With its west-facing wall of plate glass windows, the view from the house was magnificent. Looking out, one could see Sandia Mountain way down by Albuquerque, Chicoma Peak, over in the Jemez range, Canjilon Peak, up north beyond Abiquiu. Behind the house, Lake Peak was glowing in the last minutes of sunlight. Together these comprised the four sacred mountains of the Tewa Indians, who still lived in pueblos down along the Rio Grande. Murray had learned a couple of the mountain's original names from his pueblo friends, and now he started reciting them. As he gazed out at the sunset, it was clear how much he loved this house and how sad he was that he had to sell it. Marcia didn't like the spartan feel of the place—with its brick floors and unfinished wooden roof beams, it was more like a large, very nice cabin—or the long drive into town. They had recently sold the home in Pasadena where he had lived for years and had just bought a house with an indoor swimming pool in Santa Fe's expensive museum district. The house itself was

like a museum, with Murray's collections of indigenous American pottery, African art, rare books, and ancient weapons—an Eskimo harpoon, a North African mace, a blowgun complete with poison darts, a Sumatran dagger, a Chinese beheading sword. "For keeping Marcia in line," he said sardonically. He could get away with comments like that because it was so clear how devoted to her he was.

Traveling from one exotic place to another, surrounding himself with historical treasures—it seemed like a wonderful life. And yet he didn't always strike me as very happy. One day when I was talking to him on the telephone, he suddenly remembered a kindness someone had shown to him back when he was a graduate student struggling to find money to live on when his scholarship was held up. He broke off the story and fell into a reverie. "Everybody was very nice to me," he said quietly. "I must say they were just so nice to me. That's always been true. All my life people have been very, very nice to me and I usually didn't profit by the advantage." I thought he was going to cry.

After all his stalling and agonizing over the perils of talking to a biographer, I was startled at how easily he let down his guard. I guess he had just gotten used to me. One afternoon, reminiscing about the sad early death of his old mentor, Enrico Fermi, who may have slowly, unknowingly poisoned himself with radiation, Murray's voice trailed off into silence. "I don't know," he said after a long pause. "I wanted to write some of this myself, but you're so nice and so charming that I just tell you everything." He shook his head, a little exasperated at himself. I was starting to feel slightly guilty, sitting there in his office, the tape recorder rolling.