THE MAN WHO KNOWS EVERYTHING

MURRAY GELL-MANN

The discoverer of the quark is certain that complexity isn't as complicated as it looks. But writing a book sure is.

By David Berreby

SIX WRITHING LEGS GLINT LIKE copper in the strong New Mexico sun. Murray Gell-Mann, discoverer of the quark, winner of the Nobel Prize in Physics in 1969, author of a new book that attempts to explain, oh, pretty much everything, has caught an insect. He holds it delicately by its folded wings as he clambers down from the immense window where he found it crawling.

"Come on, kid," he says. The bug wriggles. Gell-Mann opens a door onto his patio and tosses the creature out among the piñons and junipers that surround his adobe mountain home near Santa Fe. "I like these fine," he says. "I just like them outside."

Does Gell-Mann know what kind of insect he's returning to nature? What a silly question. The essence of Murray Gell-Mann is to know.

"They're conenose bugs," he says. "I can't remember the Latin name at the moment. They're harmless, but they're closely related to the kissing bug, which causes Chagas' disease in the tropics. Chagas' disease is a devastating kind of sleeping sickness. It's transmitted when they bite you on the mouth while you're sleeping. Hence the genus is also known as assassin bugs. Anyway, these don't carry the organism, so they're harmless."

By the way, he adds, the white plastic net under his arm isn't really right for capturing bugs. "It's a fishing net." How does he know? He stops in his tracks. A small, stooped man with white hair curling over a pink scalp, he can look like your best friend's amiable grandfather from Brooklyn — until he encounters a thought he doesn't like. "A butterfly net would be much longer," he says, with a pained scowl and the air of one explaining that the big red light on top means "stop" and the big green one at the bottom means "go."

Even Murray Gell-Mann's credentials — a director of the John D. and Catherine T. MacArthur Foundation, member of the Council on Foreign Relations, adviser to the Pentagon on arms control, collector of prehistoric Southwest American pottery, amateur ornithologist, to name a few — can't prepare a visitor for the full extent of his erudition. He pronounces "Chagas" as it is heard in Brazil. He has been known to correct the Ukrainian pronunciation of native Ukrainians and disparage the Swahili of Kenyans. His love of language, in fact, is responsible for much of the poetic nomenclature of modern particle physics, including the word "quark" to describe the particles that, in inseparable groups, make up larger subatomic particles like protons and neutrons. Gell-Mann, who made the theoretical case for quarks in the 1960's, decided on the nonsense sound, and when he later found a reference in James Joyce's "Finnegans Wake" for "three quarks for Muster Mark," that settled the matter for good.

As his wife, Marcia Southwick, makes sandwiches at the kitchen counter, Gell-Mann explains that he's on a low-fat diet, so the tuna salad is made without something that sounds like "my own haze" — "mayonnaise" as pronounced in Paris. At the California Institute of Technology, where Gell-Mann taught from 1955 until last year, his friend, rival, fellow Nobelist and polar opposite, Richard Feynman, would occasionally feign incomprehension when Gell-Mann

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PHOTOGRAPH BY DOUGLAS MERRIAM FOR THE NEW YORK TIMES pronounced, say, "Montreal," in his special fashion. Sometimes, as when Gell-Mann enunciates the name of the anthropologist Clifford Geertz ("Hghayrts — it's a Dutch name"), you have to think Feynman wasn't always faking it.

GELL-MANN, AN AUSTRIan immigrant's son from New York City, has been doing this kind of thing for nearly all of his 64 years. (His literary agent, John Brockman, likes to say "he has five brains, and each one is smarter than yours.") His is not a know-it-all manner, but a know-it-all philosophy. He combines a mania for the smallest detail with an intellectual ambition whose confidence is strikingly out of sync with an era obsessed with the limitations of knowledge. Even many scientists nowadays do not share Gell-Mann's conviction: that it is indeed possible to know it *all*, that in principle there is nothing to prevent the future day when sovereign science will be able to explain absolutely everything, in a single coherent picture of how the universe works. That picture will inherently contain a certain amount of randomness and unpredictability, Gell-Mann says, but even then scientists will be able to explain why.

"There's something extremely admirable about that," says Seth Lloyd, a physicist at the Los Alamos National Laboratory and a friend and protégé of Gell-Mann's. "I know that's not a very fashionable point of view, but if you're going to be a scientist, particularly a great scientist like Murray, then you have to be confident that the analytical tools you apply to the world are going to work."

Gell-Mann titled his new book, published last month, "The Quark and the Jaguar," to suggest the full width of the intellectual space he wants to span. Though not an autobiography, it is a kind of *summa* of all his many interests, connecting in a single skein of thought everything from the fundamentals of matter to the need for wildlife conservation and population control, with pauses here and there for marginalia, like reports of fish falling from the skies.

It is, above all, a book about beautiful theories — triumphs of abstract thought like relativity, electromagnetism and natural selection that made the bewildering universe yield its secrets to human intelligence. Gell-Mann himself is responsible for two of the most important theories in modern particle physics, and in the book he describes what he believes will become the next great idea that will apply to jaguars, economies, human minds and all the other phenomena that particle physics doesn't consider: the theory of complexity.

Complexity theory (Gell-Mann prefers to call it "plectics") is a way of describing why the kissing bug on Gell-Mann's window is more than the sum of its parts. The basic components — atoms, molecules, cells — are each simple enough, but as they interact with one another, new properties emerge: the bug, for example, is capable of deciding whether to crawl up or down as Gell-Mann goes after it. The result, in Gell-Mann's parlance, is a "complex adaptive system," a collection of simple parts that interact to form a complex whole capable of learning about and reacting to the outside world.

Complexity theory rests on two ideas. The first is that complexity is not merely a quality to be noted but a quantity that can be measured. (Linguists, Gell-Mann says, might measure the complexity of some language by the length of its grammar.) That makes it possible to talk about levels of complexity and to say with confidence that complex things tend over time to give rise to more complex things.

The second key idea is that complex adaptive systems are everywhere alike. For example, Gell-Mann writes, the process of learning — testing a model against reality and then modifying it to suit — occurs on different time scales throughout biology. Migratory birds adapt to their environment over eons of evolution; consequently, the information they carry in their genes includes a kind of map for each bird to follow. The immune system, Gell-Mann writes, "undergoes a process very similar to biological evolution . . . but on a time scale of hours or days instead of millions of years." Where previous generations of scientists might regard that idea as a fruitful analogy, complexity theorists pursue it as possibly literally true — that there is a way of understanding complexity, using models from mathematics, physics and especially computer science, in which evolution and an immune response would be seen as fundamentally similar. (Complexity theory, it should be noted, is related to chaos theory, which is the study of systems — the stock market, say, or weather and traffic patterns — that can be altered in enormous and often unpredictable ways by even the slightest change in input.)

Gell-Mann's personal prestige and network of contacts have had much to do with the current vogue for complexity theory. In 1984, he and several physicists from the nearby Los Alamos National Laboratory founded the North American mecca of complexity research, the Santa Fe Institute. Lodged in a nondescript office complex, the institute is a warren of 35 offices and a few conference rooms, all crammed with computers and books. Some 200 researchers a year from a variety of disciplines walk up and down the stairs and through little courtyards, coalescing to discuss this problem or that in a kind of ongoing, high-intellect show-and-tell of blackboard scribbling and computer simulation. Like other participants, Gell-Mann, who is a trustee of the institute and co-chairman of its science board, wanders about, listening to and buttonholing other researchers. But his is a special role. With his vast knowledge, he is a useful link between disciplines that often use mutually incomprehensible notations and concepts. Admittedly, much of the work remains to be done. "Of course, the real goal is verification," Gell-Mann says. "Predicting things that are then found to be true. We don't have a lot of that to show yet. But we will. You have to be patient. You should give it 20 years."

IT IS ENTIRELY IN CHARACTER that Gell-Mann should be promoting the biggest and most wide-ranging of new ideas in science. Throughout his career, his eye was always on the biggest prize, the most capacious theory. When the physicist and writer Jeremy Bernstein won a National Science Foundation fellowship in 1959, Gell-Mann persuaded him to come to Paris. "Stick with me, kid," Bernstein recalls Gell-Mann saying, "and I will put you on Broadway."

Gell-Mann did indeed reach physics Broadway. The Standard Model of reality that physicists use to guide their theorizing and experiments would not exist were it not for two major contributions by Murray Gell-Mann. As early as the 1950's, he was attempting to find unity in what others saw as a bewildering assortment of unrelated subatomic particles. By 1961, Gell-Mann had circulated a paper around Caltech proposing a unifying scheme in which to class the new particles, often in groups of eight. Gell-Mann dubbed it "the eightfold way" in puckish homage to the Buddhist path to nirvana. The scheme succeeded in classifying a vast array of particles according to underlying properties that were not at all apparent at first, second or even third glance. The eightfold way often has been compared to a 20th-century periodic table in its predictive power. The scheme foretold the existence of a variety of particles that had not yet been detected. As the 1960's progressed, the particles were all discovered, precisely where they were supposed to be. Gell-Mann won the Nobel Prize in 1969.

Attempting to refine the eightfold way, Gell-Mann and his collaborators proposed that some of the fundamental particles of the atom could be

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understood as made up of even smaller components. These were the quarks, and though the original proposal had to be made more complicated, by the mid-1970's the quark concept, too, had been resoundingly confirmed by discoveries in particle accelerators. Two weeks ago — on the morning after Gell-Mann's book party — physicists at the Fermi National Accelerator Laboratory announced that they had found evidence of the so-called top quark, the last holdout of the six quarks predicted by Gell-Mann.

At the Santa Fe Institute, Gell-Mann's combination of intellectual grandeur and mania for detail is well known. He constantly urges his colleagues to stretch further — and explain more. "Murray pushes people with a nice abstract model to connect it more to the real world," says L. M. Simmons, the institute's vice president of academic affairs. "Sometimes he presses a little too hard. Sometimes you have to crawl before you can walk. But Murray's point is: Always think about walking."

The Gell-Mann treatment is not always pleasant. Scientists who work in solid-state physics do not appreciate his oft-quoted description of the field as "squalid-state physics." Over dinner and a carefully chosen bottle of wine in a quiet Santa Fe restaurant, Gell-Mann cannot resist a passing reference to "the good Gleick," the scientist brother of James Gleick, author of "Genius," the best-selling biography of Feynman. The book's portrayal of Gell-Mann was not nearly as flattering as he would have liked.

Murray Gell-Mann with his wife, Marcia Southwick, at Caltech.

On the other hand, Gell-Mann's praise can be as warm and sunny as his impatience is cold and hard. When he describes a naturalist or a chemist as a "brilliant, wonderful guy," his enthusiasm fills the room.

"He's only rude to people when he thinks they're wrong and that what they're saying obscures the right way of looking at things," Lloyd says. "Which means that the things that make him obnoxious to some people are the same things that make him a great scientist."

In any event, no one has ever claimed that Gell-Mann isn't just as hard on himself. "The Quark and the Jaguar" was agony for him to write, and a considerable pain to live through for his friends and colleagues. After his huge ambition and equally huge advances from publishers around the world were ballyhooed at the 1990 Frankfurt Book Fair, anything much less than a best seller will make the book "the 'Heaven's Gate' of popular-science publishing," says an acquaintance. (A brief review in The New York Times Book Review last Sunday labeled his musings "unremarkable.") Gell-Mann's absorption in "The Quark and the Jaguar" reduced his mental presence at the Santa Fe Institute and at Los Alamos. Some friends say it even had something to do with the mild heart attack he suffered late in 1992.

Uneasy with any work that isn't world-class perfect, Gell-Mann for years found writing excruciating, and the book was no exception. His agent thought a ghost writer would help. Gell-Mann plowed through three. One, who had helped produce the 32-page proposal that sold the book, bowed out after that point and wrote his own book ("Complexity," by Roger Lewin); the next one simply couldn't bear the flaws Gell-Mann would find in everything he wrote and dropped out; a third wisely decided his three-month job was only to edit and encourage as Gell-Mann agonized over his own hen-scratchings. The chapters Gell-Mann finally delivered were written by no one but himself.

By then, having fallen far behind schedule, Gell-Mann was dropped by his first publisher; he found a second one, but nearly exhausted its patience with his last-minute corrections. "I had people calling me up every day, threatening me," Gell-Mann says. "It took years off my life."

"Ours, too," says a source at W. H. Freeman & Company who was close to the production process. "Let's just say Freeman's been pretty flexible. In fact, let's say no other author has pushed us this far. I don't want them to get the idea they can."

With the book completed, it's time now for Gell-Mann to return to the Olympian task of finding out how the bug and Chagas' disease and all other scientific knowledge fit together. Gell-Mann says certain sciences are "more fundamental" than others, as physics is more fundamental then chemistry. Each subject has its own, useful theoretical tools, he says, but it is also important to work on the "staircases" or "bridges" that will connect the various levels of inquiry into a single coherent house of knowledge. For example, Gell-Mann writes, the well-developed laws of chemistry can explain why two hydrogen atoms link together in a molecule. But more complicated bridgework would be required if, say, a theoretical chemist wanted to relate those laws to the more fundamental science of physics, which describes how the electrons in the hydrogen atoms act to connect the pair.

Gell-Mann's colleagues, however, are divided on whether such bridges and ladders can ever be built. Knowledge of how simple things come together in complex systems "is not seamless," says George Cowan, a former Los Alamos nuclear scientist who also helped found the Santa Fe Institute and served as its first president. As a system becomes more complex, Cowan says, "things arise that we call 'emergent properties' or, with more honesty, 'things we don't understand.' " Because the properties are not understood, he says, it's far from clear that the different kinds of knowledge represented by biology, chemistry, physics and psychology will one day neatly fold into one another. "These are the opening rounds of something that's going to go on for a long time."

But, Cowan adds, "Murray wants an all-embracing view. It comes of the success he's had by assuming that there had to be a fundamental elegance and beauty in subatomic particles. That led to quarks, so the faith paid off. In complexity, the jury is still out."

A MESSAGE: "CALL Murray." We've said goodbye only a few hours before.

"Those insects," Gell-Mann says when he is reached on the phone from "inside the fence," where people with security clearance work at the Los Alamos National Laboratory. "The family is Reduviidae. I don't know how I could have forgotten. And I said they didn't carry Chagas' disease. That's not right. They *do* carry it. But apparently they don't transmit it, because they don't defecate while feeding. The way the disease is carried by their relatives is that they bite you on the lips and defecate and then you smear the feces into the wounds when you wipe your lips. So what I said before was not quite right."

Gell-Mann's voice on the phone is warm, cheerful, deeply happy that any misapprehension he may have spread about the kissing bug has been corrected, that the tiniest of details is now precisely right. "Thanks," he says. "Thanks so much for calling back." ■

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