THE QUANTS

How a New Breed of Math Whizzes Conquered Wall Street and Nearly Destroyed It

SCOTT PATTERSON
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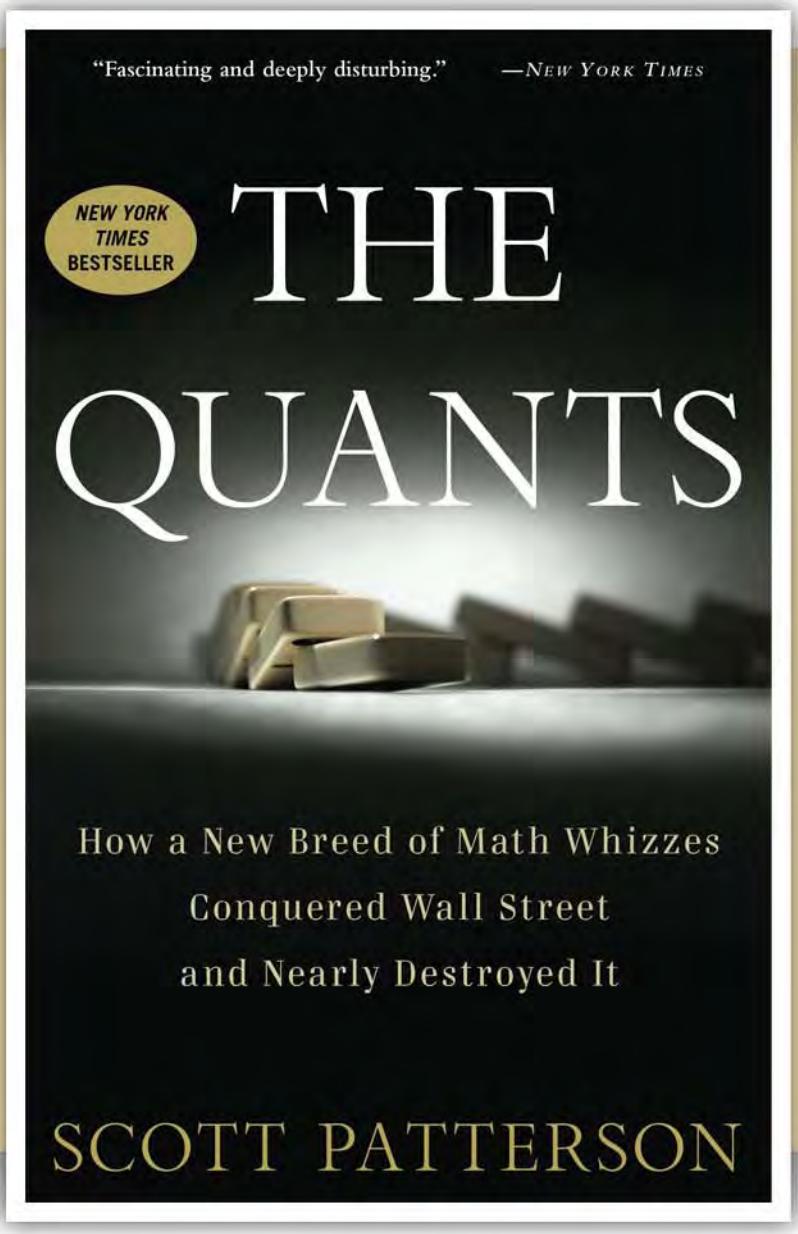

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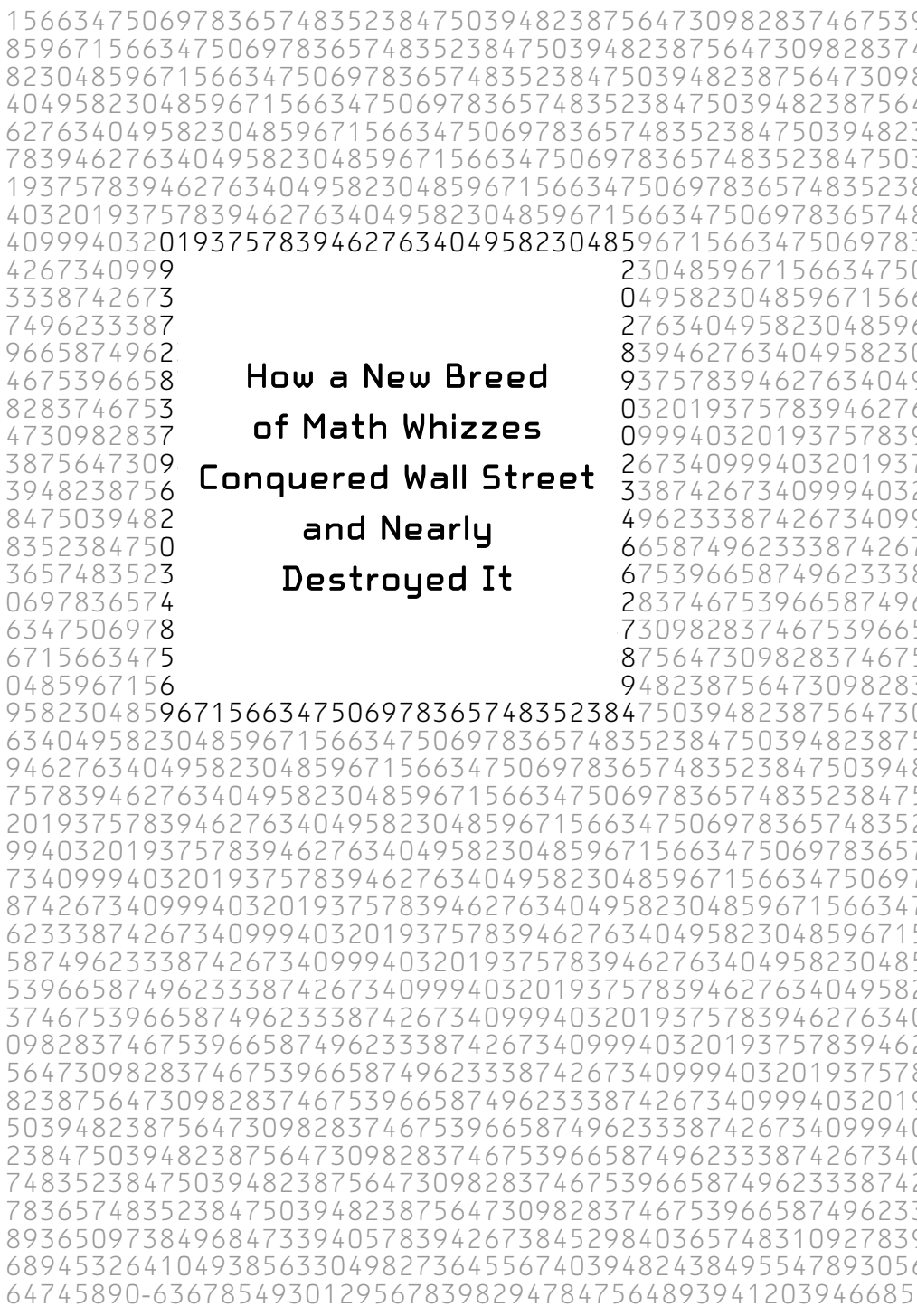
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Peter Muller, outspokenly eccentric manager of Morgan Stanley's secretive hedge fund PDT. A whip-smart mathematician who occasionally took to New York's subways to play his keyboard for commuters, in 2007 Muller had just returned to his hedge fund after a long sabbatical, with grand plans of expanding operations and juicing returns even further.

Ken Griffin, tough-as-nails manager of Chicago hedge fund Citadel Investment Group, one of the largest and most successful funds in the world. In the years before the crash, Griffin's indulgences included the purchase of an $80 million Jasper Johns painting and a Paris wedding at the Palace of Versailles.

Cliff Asness, sharp-tongued, hot-tempered founder of AQR Capital Management, a hedge fund with nearly $40 billion in assets under management at the time of the crash. Mere days before the crash, Asness's hedge fund was on the verge of filing the final papers for an initial public offering.

Boaz Weinstein, chess "life master," card counter, and powerful derivatives trader at Deutsche Bank, who built his internal hedge fund, Saba (Hebrew for "wise grandfather"), into one of the most powerful credit-trading funds on the planet, juggling $30 billion worth of positions.

Jim Simons, the reclusive, highly secretive billionaire manager of Renaissance Technologies, the most successful hedge fund in history, whose mysterious investment techniques are driven by scientists

poached from the fields of cryptoanalysis and computerized speech recognition.

Ed Thorp, godfather of the quants. As a math professor in the 1950s, Thorp deployed his mathematical skills to crack blackjack, unifying the key themes of gambling and investing, and later became the first math genius to figure out how to use similar skills to make millions on Wall Street.

Aaron Brown, the quant who used his math smarts to thoroughly humiliate Wall Street's old guard at their trademark game of Liar's Poker, and whose career provided him with a front-row view of the explosion of the mortgage-backed securities industry.

Paul Wilmott, quant guru extraordinaire and founder of the mathematical finance program at Oxford University. In 2000, Wilmott began warning of a mathematician-led market meltdown.

Benoit Mandelbrot, mathematician who as early as the 1960s warned of the dangers wild market swings pose to quant models—but was soon forgotten in the world of quants as little more than a footnote in their long march to a seemingly inevitable victory.

"We have involved ourselves in a colossal muddle, having blundered in the control of a delicate machine, the working of which we do not understand. The result is that our possibilities of wealth may run to waste for a time—perhaps for a long time."

—John Maynard Keynes,
The Great Slump of 1930

Peter Muller stepped into the posh Versailles Room of the century-old St. Regis Hotel in midtown Manhattan and took in the glittering scene in a glance.

It wasn't the trio of cut-glass chandeliers hung from a gilt-laden ceiling that caught his attention, nor the pair of antique floor-to-ceiling mirrors to his left, nor the guests' svelte Armani suits and gem-studded dresses. Something else in the air made him smile: the smell of money. And the sweet perfume of something he loved even more: pure, unbridled testosterone-fueled competition. It was intoxicating, and it was all around him, from the rich fizz of a fresh bottle of champagne popping open to the knowing nods and winks of his friends as he moved into a room that was a virtual murderer's row of topflight bankers and hedge fund managers, the richest in the world. His people.

It was March 8, 2006, and the Wall Street Poker Night Tournament

was about to begin. More than a hundred well-heeled players milled about the room, elite traders and buttoned-down dealmakers by day, gambling enthusiasts by night. The small, private affair was a gathering of a select group of wealthy and brilliant individuals who had, through sheer brainpower and a healthy dose of daring, become the new tycoons of Wall Street. This high-finance haut monde—perhaps Muller most of all—was so secretive that few people outside the room had ever heard their names. And yet, behind the scenes, their decisions controlled the ebb and flow of billions of dollars coursing through the global financial system every day.

Mixed in with the crowd were professional poker players such as T. J. Cloutier, winner of sixty major tournaments, and Clonie Gowen, a blond Texan bombshell with the face of a fashion model and the body of a *Playboy* pinup. More important to the gathering crowd, Gowen was one of the most successful female poker players in the country.

Muller, tan, fit, and at forty-two looking a decade younger than his age, a wiry Pat Boone in his prime, radiated the relaxed cool of a man accustomed to victory. He waved across the room to Jim Simons, billionaire math genius and founder of the most successful hedge fund on the planet, Renaissance Technologies. Simons, a balding, white-bearded wizard of quantitative investing, winked back as he continued chatting with the circle of admirers hovering around him.

The previous year, Simons had pocketed $1.5 billion in hedge fund fees, at the time the biggest one-year paycheck ever earned by a hedge fund manager. His elite team of traders, hidden away in a small enclave on Long Island, marshaled the most mind-bending advances in science and mathematics, from quantum physics to artificial intelligence to voice recognition technology, to wring billions in profits from the market. Simons was the rare investor who could make Muller feel jaw-clenchingly jealous.

The two had known each other since the early 1990s, when Muller briefly considered joining Renaissance before starting his own quantitative hedge fund inside Morgan Stanley, the giant New York investment bank. Muller's elite trading group, which he called Process Driven Trading, was so secretive that even most employees at Morgan weren't aware of its existence. Yet over the previous decade the group,

composed of only about fifty people, had racked up a track record that could go toe-to-toe with the best investment outfits on Wall Street, cranking out $6 billion in gains for Morgan.

Muller and Simons were giants among an unusual breed of investors known as "quants." They used brain-twisting math and superpowered computers to pluck billions in fleeting dollars out of the market. By the early 2000s, such tech-savvy investors had come to dominate Wall Street, helped by theoretical breakthroughs in the application of mathematics to financial markets, advances that had earned their discoverers several shelves of Nobel Prizes. The quants applied those same breakthroughs to the highly practical, massively profitable practice of calculating predictable patterns in how the market moved and worked.

These computer-driven investors couldn't care less about a company's "fundamentals," amorphous qualities such as the morale of its employees or the cut of its chief executive's jib. That was for the dinosaurs of Wall Street, the Warren Buffetts and Peter Lynches of the world, investors who focused on factors such as what a company actually made and whether it made it well. Quants were agnostic on such matters, devoting themselves instead to predicting whether a company's stock would move up or down based on a dizzying array of numerical variables such as how cheap it was relative to the rest of the market, how quickly the stock had risen or declined, or a combination of the two—and much more.

That night at the St. Regis was a golden hour for the quants, a predators' ball for the pocket-protector set. They were celebrating their dominance of Wall Street, just as junk bond kings such as Michael Milken had ruled the financial world in the 1980s or swashbuckling, trade-from-the-hip hedge fund managers such as George Soros had conquered the Street in the 1990s.

Muller flicked a lock of sandy brown hair from his eyes and snatched a glass of wine from a passing tray, looking for his friends. A few nonquants, fundamental investors of the old guard, rubbed elbows with the quant crowd that night. David Einhorn, the boy-faced manager of Greenlight Capital (so named when his wife gave him the green light to launch a fund in the 1990s), could be seen chatting on a

cell phone by a tall, narrow window overlooking the corner of 55th Street and Fifth Avenue. Just thirty-seven years old, Einhorn was quickly gaining a reputation as one of the sharpest fundamental investors in the business, putting up returns of 20 percent or more year after year. Einhorn was also an ace poker player who would place eighteenth in the World Series of Poker in Las Vegas the following year, winning $659,730.

The next billionaire Muller spotted was Ken Griffin, the blue-eyed, notoriously ruthless manager of Chicago's Citadel Investment Group, one of the largest and most successful hedge funds in the business. Grave dancer of the hedge funds, Citadel was known for sweeping in on distressed companies and gobbling up the remains of the bloodied carcasses. But the core engines of his fund were computer-driven mathematical models that guided its every move. Griffin, who sported a no-nonsense buzz cut of jet-black hair, was the sort of man who triggered a dark sense of foreboding even in close associates: *Wouldn't want to mess with Ken in a dark alley. Does he ever smile? The guy wants to be king of everything he touches*.

"Petey boy."

Muller felt a jolt in his back. It was his old friend and poker pal Cliff Asness, manager of AQR Capital Management, among the first pure quant hedge funds. Asness, like Muller, Griffin, and Simons, was a pioneer among the quants, having started out at Goldman Sachs in the early 1990s.

"Decided to grace us tonight?" he said.

Asness knew Muller wouldn't miss this quant poker coronation for the world. Muller was obsessed with poker, had been for years. He'd recently roped Asness into a private high-stakes poker game played with several other traders and hedge fund hotshots in ritzy Manhattan hotel rooms. The game had a $10,000 buy-in, couch cushion change to topflight traders such as Asness and Muller.

The quants ran the private poker game, but more traditional investment titans joined in. Carl Icahn, the billionaire financier who'd gotten his start on Wall Street with $4,000 in poker winnings, was a regular. So was Marc Lasry, manager of Avenue Capital Group, the $12 billion hedge fund that would hire former first daughter Chelsea Clinton

later that year. Lasry was known for being a cool investor whose icy demeanor belied his let-it-roll mentality. He was said to have once wagered $100,000 on a hand without even looking at his cards. And won.

The real point of Asness's needle was that he never knew when the globetrotting Muller would be in town. One week he'd be trekking in Bhutan or white-water rafting in Bolivia, the next heli-skiing in the Grand Tetons or singing folk songs in a funky cabaret in Greenwich Village. Muller had even been spotted belting out Bob Dylan tunes in New York's subway system, his keyboard case sprinkled with coins from charitable commuters with no idea the seemingly down-on-his-luck songster was worth hundreds of millions and flew around in a private jet.

Asness, a stocky, balding man with a meaty face and impish blue eyes, wore khaki pants and a white tee peeking out from his open collar. He winked, stroking the orange-gray stubble of his trimmed beard. Though he lacked Muller's savoir faire, Asness was far wealthier, manager of his own hedge fund, and a rising power in the investment world. His firm, AQR, short for Applied Quantitative Research, was managing $25 billion and growing fast.

The year before, Asness had been the subject of a lengthy and glowing profile in the *New York Times Magazine.* He was a scourge of bad practices in the money management industry, such as ridiculously high fees at mutual funds. And he had the intellectual chops to back up his attacks. Known as one of the smartest investors in the world, Asness had worked hard for his success. He'd been a standout student at the University of Chicago's prestigious economics department in the early 1990s, then a star at Goldman Sachs in the mid-1990s before branching out on his own in 1998 to launch AQR with $1 billion and change, a near record at the time. His ego had grown along with his wallet, and so, too, had his temper. While outsiders knew Asness for his razor-sharp mind tempered by a wry, self-effacing sense of humor, inside AQR he was known for flying into computer-smashing rampages and shooting off ego-crushing emails to his cowed employees at all hours of the day or night. His poker buddies loved Asness's cutting wit and encyclopedic memory, but they'd also seen his darker side, his volatile temper and sudden rages at a losing hand.

"Here comes Neil," Asness said, nodding toward Neil Chriss. A quiet, cerebral mathematician with degrees from the University of Chicago and Harvard, Chriss had cut his teeth on Wall Street at Morgan Stanley, where he'd met Muller. In 1998, he took a job at Goldman Sachs Asset Management just after Asness had left. By 2004, Chriss was quietly building a cutting-edge quant machine at a giant hedge fund called SAC Capital Advisors, run by the eccentric and reclusive tycoon Steve A. Cohen. He was also a member of the quants' poker-playing inner circle.

"Seen Boaz?" Chriss asked, scanning the room.

They looked for the fourth member of their private poker game, Boaz Weinstein. Just thirty-three, Weinstein was head of all credit trading in the United States at Deutsche Bank, the German behemoth. A chess "life master," he'd made vice president at Deutsche in 1999 at the tender age of twenty-five. Two years later, he was named a managing director of the firm, one of the youngest in the bank's history. He ran a wildly successful internal hedge fund at Deutsche that he planned to name Saba, Hebrew for "wise grandfather" (in honor of his own saba). A few times a year, Weinstein jetted off to Las Vegas along with members of MIT's secretive blackjack team, several of whom had worked on Deutsche's trading floor. The team had already gained fame in the bestseller *Bringing Down the House* and was soon to get the Hollywood treatment in the movie 21. People who knew him said Weinstein's name was on more than one Vegas casino's blacklist. He didn't care. There were plenty of casinos, none better than the one he played in every day from his third-floor office in downtown Manhattan. Wall Street.

"Over there," said Muller, pointing to Weinstein, dough-faced, brown-haired, typing rapidly on a BlackBerry while chatting up Gowen. Asness whistled and cleared his throat.

The players soon got down to business. A melodic chime summoned stragglers into the main room, where vested dealers waited behind scattered rows of card tables, fresh decks arrayed in wide rainbows before them. The game was Texas Hold'em. The action was cordial on the surface, cutthroat between the lines. It was a charity event, after all. Nearly $2 million in proceeds would go to support a math pro-

gram for New York City's public schools—a fitting beneficiary, as the players were Wall Street's glorified mathletes. Muller, Asness, Griffin, and Weinstein were all quants. Math was the very air they breathed. Even the custom-made poker chips at the event were stamped with the names of mathematical river gods such as Isaac Newton.

The potent combination of their mathematical brilliance, feverishly competitive natures, and out-on-the-edge gambling instincts led to an almost fanatical obsession with poker—the odds, the looping mental games, the bluffing (*if I bet this much, he'll think that I think that he thinks* . . .). Asness didn't take the game as seriously as Muller, Weinstein, and Chris did. He'd picked it up in the past few years after an internal tournament at AQR (which he happened to win). But the guys he was playing against were *insane* about poker. Muller had been frequenting poker halls since the 1980s during his days as a young quant in Berkeley, California. In 2004, he'd become so serious about the game—and so good at it—that he joined the World Poker Tour, pocketing nearly $100,000 in winnings. He played online poker obsessively and even toyed with the bizarre notion of launching an online poker hedge fund. Weinstein, more of a blackjack man, was no slouch at the poker table, having won a Maserati in a 2005 NetJets poker tournament. Griffin simply hated to lose to anyone at anything and approached the poker table with the same brainiac killer instinct that infused his day-to-day trading prowess.

No matter how hard they might play elsewhere, no poker game mattered more than when the gamblers around the table were their fellow quants. It was more than a battle of wits over massive pots—it was a battle of enormous egos. Every day they went head-to-head on Wall Street, facing off in a computerized game of high-stakes poker in financial markets around the globe, measuring one another's wins and losses from afar, but here was a chance to measure their mettle face-to-face. Each had his own particular strategy for beating the market. Griffin specialized in finding cheap bonds through mathematical formulas, or, via the same logic, cheap, down-on-their-luck companies ripe for the picking. Muller liked to buy and sell stocks at a superfast pace using Morgan Stanley's high-powered computers. Asness used historical tests of market trends going back decades to detect hidden

patterns no one else knew about. Weinstein was a wizard with credit derivatives—securities whose value derives from some underlying asset, such as a stock or a bond. Weinstein was especially adept with a newfangled derivative known as a credit default swap, which is essentially an insurance policy on a bond.

Regardless of which signature trade each man favored, they had something far more powerful in common: an epic quest for an elusive, ethereal quality the quants sometimes referred to in hushed, reverent tones as the Truth.

The Truth was a universal secret about the way the market worked that could only be discovered through mathematics. Revealed through the study of obscure patterns in the market, the Truth was the key to unlocking billions in profits. The quants built giant machines—turbocharged computers linked to financial markets around the globe—to search for the Truth, and to deploy it in their quest to make untold fortunes. The bigger the machine, the more Truth they knew, and the more Truth they knew, the more they could bet. And from that, they reasoned, the richer they'd be. Think of white-coated scientists building ever more powerful devices to replicate conditions at the moment of the Big Bang to understand the forces at the root of creation. It was about money, of course, but it was also about proof. Each added dollar was another tiny step toward proving they had fulfilled their academic promise and uncovered the Truth.

The quants created a name for the Truth, a name that smacked of cabalistic studies of magical formulas: alpha. *Alpha* is a code word for an elusive skill certain individuals are endowed with that gives them the ability to consistently beat the market. It is used in contrast with another Greek term, *beta*, which is shorthand for plain-vanilla market returns anyone with half a brain can achieve.

To the quants, beta is bad, alpha is good. Alpha is the Truth. If you have it, you can be rich beyond your wildest dreams.

The notion of alpha, and its ephemeral promise of vast riches, was everywhere in the hedge fund world. The trade magazine of choice for hedge funds was called *Alpha*. A popular website frequented by the hedge fund community was called Seeking Alpha. Sev-

eral of the quants in the room had already laid claim, in some form or another, to the possession of alpha. Asness named his first hedge fund, hatched inside Goldman in the mid-1990s, Global Alpha. Before moving on to Morgan in 1992, Muller had helped construct a computerized investing system called Alphabuilder for a quant farm in Berkeley called BARRA. An old poster from a 1960s film noir by Jean-Luc Godard called *Alphaville* hung on the walls of PDT's office in Morgan's midtown Manhattan headquarters.

But there was always a worry haunting the beauty of the quants' algorithms. Perhaps their successes weren't due to skill at all. Perhaps it was all just dumb luck, fool's gold, a good run that could come to an end on any given day. What if the markets weren't predictable? What if their computer models didn't always work? What if the truth wasn't knowable? Worse, what if there wasn't any Truth?

In their day jobs, as they searched for the Truth, channeling their hidden alpha nerds, the quants were isolated in their trading rooms and hedge funds. At the poker table, they could look one another in the eye, smiling over their cards as they tossed another ten grand worth of chips on the table and called, looking for the telltale wince of the bluffer. Sure, it was a charity event. But it was also a test. Skill at poker meant skill at trading. And it potentially meant something even more: the magical presence of alpha.

As the night rolled on, the quants fared well. Muller chalked up victories against Gowen and Cloutier in the early rounds. Weinstein was knocked out early, but Muller and Asness kept dominating their opponents. Griffin made it into the final ten before running out of luck and chips, as did Einhorn. The action got more intense as the hour grew late. Around 1:30 A.M., only three players were left: Muller, Asness, and Andrei Paraschivescu, a portfolio manager who worked for Griffin at Citadel.

Asness didn't like his first two cards on the next deal and quickly folded, happy to wait for a better draw, leaving the pot to Muller and Paraschivescu. The crowd fell quiet. The incessant honking city whir of Fifth Avenue penetrated the suddenly hushed room.

Breaking the silence, Griffin shouted a warning to his underling:

"Andrei, don't bother coming into work next week if you don't knock Pete out." Some in the crowd wondered if he meant it. With Griffin, you never knew.

The room went quiet again. Paraschivescu lifted a corner of the two cards facedown on the table before him. Pair of fours. Not bad. Muller bent the corner of his two cards and eyed a pair of kings. He decided to go all in, sweeping his chips into the pot. Suspecting a bluff, Paraschivescu pushed his mound of chips forward and called, flipping over his pair of fours. Muller showed his kings, his only show of emotion a winsome glint in his blue eyes. A groan went up from the crowd, the loudest from Griffin. The other cards dealt in the hand couldn't help Paraschivescu, and he was out.

It was down to Muller and Asness, quant versus quant. Asness was at a huge disadvantage. Muller outchipped him eight to one after having taken Paraschivescu to the cleaners. Asness would have to win several hands in a row to even have a chance. He was at Muller's mercy.

Griffin, still smarting from his ace trader's loss, promised to donate $10,000 to Asness's favorite charity if he beat Muller. "Aren't you a billionaire?" Asness chortled. "That's a little chintzy, Ken."

After the deal, Muller had a king and a seven. Not bad, but not great. He decided to go all in anyway. He had plenty of chips. It looked like a bad move: Asness had a better hand, an ace and a ten. As each successive card was dealt, it looked as though Asness was sure to take the pot. But on the final card, Muller drew another king. Odds were against it, but he won anyway. The real world works like that sometimes.

The crowd applauded as Griffin rained catcalls on Muller. Afterward Muller and Asness posed for photos with their silver trophies and with Clonie Gowen flashing a million-dollar smile between them. The biggest grin belonged to Muller.

As the well-heeled crowd of millionaires and billionaires fanned into the streets of Manhattan that night, they were on top of the world. The stock market was in the midst of one of the longest bull runs in history. The housing market was booming. Economists were full of talk of a Goldilocks economy—not too hot, not too cold—in which steady growth would continue as far as the eye could see.

A brilliant Princeton economist, Ben Bernanke, had just taken over the helm of the Federal Reserve from Alan Greenspan. In February 2004, Bernanke had given a speech in Washington, D.C., that captured the buoyant mood of the times. Called "The Great Moderation," the speech told of a bold new economic era in which volatility—the jarring jolts and spasms that wreaked havoc on people's lives and their pocketbooks—was permanently eradicated. One of the primary forces behind this economic Shangri-la, he said, was an "increased depth and sophistication of financial markets."

In other words, quants, such as Griffin, Asness, Muller, Weinstein, Simons, and the rest of the math wizards who had taken over Wall Street, had helped tame the market's volatility. Out of chaos they had created order through their ever-increasing knowledge of the Truth. Every time the market lurched too far out of equilibrium, their supercomputers raced to the rescue, gobbling up the mispriced securities and restoring stability to the troubled kingdom. The financial system had become a finely tuned machine, humming blissfully along in the crystalline mathematical universe of the quants.

For providing this service to society, the quants were paid handsomely. But who could complain? Average workers were seeing their 401(k)s rise with the market, housing prices kept ticking ever upward, banks had plenty of money to lend, prognosticators imagined a Dow Jones Industrial Average that rose without fail, year after year. And much of the thanks went to the quants. It was a great time to be alive and rich and brilliant on Wall Street.

The money poured in, *crazy* money. Pension funds across America, burned by the dot-com collapse in 2000, rushed into hedge funds, the favored vehicle of the quants, entrusting their members' retirement savings to this group of secretive and opaque investors. Cliff Asness's hedge fund, AQR, had started with $1 billion in 1998. By mid-2007, its assets under management neared $40 billion. Citadel's kitty topped $20 billion. In 2005, Jim Simons announced that Renaissance would launch a fund that could juggle a record $100 billion in assets. Boaz Weinstein, just thirty-three, was wielding roughly $30 billion worth of positions for Deutsche Bank.

The growth had come rapid-fire. In 1990, hedge funds held $39

billion in assets. By 2000, the amount had leapt to $490 billion, and by 2007 it had exploded to $2 trillion. And those figures didn't capture the hundreds of billions of hedge fund dollars marshaled by banks such as Morgan Stanley, Goldman Sachs, Citigroup, Lehman Brothers, Bear Stearns, and Deutsche Bank, which were rapidly transforming from staid white-shoe bank companies into hot-rod hedge fund vehicles fixated on the fast buck—or the trillions more in leverage that juiced their returns like anabolic steroids.

The Great Hedge Fund Bubble—for it was a true bubble—was one of the most frenzied gold rushes of all time. Thousands of hedge fund jockeys became wealthy beyond their wildest dreams. One of the quickest tickets to the party was a background in math and computer science. On Wall Street Poker Night in 2006, Simons, Griffin, Asness, Muller, and Weinstein sat at the top of the heap, living outsized lives of private jets, luxury yachts, and sprawling mansions.

A year later, each of the players in the room that night would find himself in the crosshairs of one of the most brutal market meltdowns ever seen, one they had helped to create. Indeed, in their search for Truth, in their quest for alpha, the quants had unwittingly primed the bomb and lit the fuse for the financial catastrophe that began to explode in spectacular fashion in August 2007.

The result was possibly the biggest, fastest, and strangest financial collapse ever seen, and the starting point for the worst global economic crisis since the Great Depression.

Amazingly, not one of the quants, despite their chart-topping IQs, their walls of degrees, their impressive Ph.D.'s, their billions of wealth earned by anticipating every bob and weave the market threw their way, their decades studying every statistical quirk of the market under the sun, saw the train wreck coming.

How could they have missed it? What went wrong?

A hint to the answer was captured centuries ago by a man whose name emblazoned the poker chips the quants wagered with that night: Isaac Newton. After losing £20,000 on a vast Ponzi scheme known as the South Sea Bubble in 1720, Newton observed: "I can calculate the motion of heavenly bodies but not the madness of people."

THE GODFATHER: ED THORP

Just past 5:00 A.M. on a spring Saturday in 1961, the sun was about to dawn on a small, ratty casino in Reno, Nevada. But inside there was perpetual darkness punctuated by the glow of neon lights. A blackjack player sat at an otherwise empty table, down $100 and exhausted. Ed Thorp was running on fumes but unwilling to quit.

"Can you deal me two hands at once?" he asked the dealer, wanting to speed up play.

"No can do," she said. "House policy."

Thorp stiffened. "I've been playing two hands all night with other dealers," he shot back.

"Two hands would crowd out other players," she snapped, shuffling the deck.

Thorp looked around at the empty casino. *She'll do whatever it takes to keep me from winning.*

The dealer started rapidly shooting out cards, trying to rattle him. At last, Thorp spied the edge he'd been waiting for. Finally—*maybe*—he'd have a chance to prove the merits of his blackjack system in the real-world crucible of a casino. Twenty-eight, with dark hair and a tendency to talk out of the corner of his mouth, Thorp resembled hordes of young men who passed through Nevada's casinos hoping to line their pockets with stacks of chips. But Thorp was different. He was a full-blown genius, holder of a Ph.D. in physics from UCLA, a professor at the Massachusetts Institute of Technology, and an expert in devising strategies to beat all kinds of games, from baccarat to blackjack.

As night stretched into morning, Thorp had kept his bets small, wagering $1 or $2 at a time, as he fished for flaws in his system. None was apparent, yet his pile of chips kept shrinking. Lady Luck was running against him. But that was about to change. It had nothing to do with luck and everything to do with math.

Thorp's system, based on complex mathematics and hundreds of hours of computer time, relied primarily on counting the number of ten cards that had been dealt. In blackjack, all face cards—kings, queens, and jacks—count as tens along with the four natural tens in every deck of fifty-two cards. Thorp had calculated that when the ratio of tens left in the deck relative to other cards increased, the odds turned in his favor. For one thing, it increased the odds that the dealer would bust, since dealers always had to "hit," or take another card, when their hand totaled sixteen or less. In other words, the more heavily a deck was stacked with ten cards, the better Thorp's chances of beating the dealer's hand and winning his bet. Thorp's tens strategy, otherwise known as the hi-lo strategy, was a revolutionary breakthrough in card counting.

While he could never be certain about which card would come next, he did know that statistically he had an edge according to one of the most fundamental rules in probability theory: the law of large numbers. The rule states that as a sample of random events, such as coin flips—or hands in a game of blackjack—increases, the expected average also becomes more certain. Ten flips of a coin could produce seven heads and three tails, 70 percent heads, 30 percent tails. But ten

thousand flips of a coin will *always* produce a ratio much closer to 50–50. For Thorp's strategy, it meant that because he had a statistical edge in blackjack, he might lose some hands, but if he played enough hands he would always come out on top—as long as he didn't lose all of his chips.

As the cards shot from the dealer's hands, Thorp saw through his exhaustion that the game was tipping his way. The deck was packed full of face cards. *Time to roll*. He upped his bet to $4 and won. He let the winnings ride and won again. His odds, he could tell, were improving. *Go for it*. He won again and had $16, which turned into $32 with the next hand. Thorp backed off, taking a $12 profit. He bet $20—and won. He kept betting $20, and kept winning. He quickly recovered his $100 in losses and then some. *Time to call it a night*.

Thorp snatched up his winnings and turned to go. As he glanced back at the dealer, he noticed an odd mixture of anger and awe on her face, as if she'd caught a glimpse of something strange and impossible that she could never explain.

Thorp, of course, was proving it wasn't impossible. It was all too real. The system worked. He grinned as he stepped out of the casino into a warm Nevada sunrise. He'd just beaten the dealer.

Thorp's victory that morning was just the beginning. Soon he would move on to much bigger game, taking on the fat cats on Wall Street, where he would deploy his formidable mathematical skills to earn hundreds of millions of dollars. Thorp was the original quant, the trailblazer who would pave the way for a new breed of mathematical traders who decades later would come to dominate Wall Street—and nearly destroy it.

Indeed, many of the most important breakthroughs in quant history derived from this obscure, puckish mathematician, one of the first to learn how to use pure math to make money—first at the blackjack tables of Las Vegas and then in the global casino known as Wall Street. Without Thorp's example, future financial titans such as Griffin, Muller, Asness, and Weinstein might never have converged on the St. Regis Hotel that night in March 2006.

■ ■ ■

Edward Oakley Thorp was always a bit of a troublemaker. The son of an army officer who'd fought on the Western Front in World War I, he was born in Chicago on August 14, 1932. He showed early signs of math prowess, such as mentally calculating the number of seconds in a year, by the time he was seven. His family eventually moved to Lomita, California, near Los Angeles, and Thorp turned to classic whiz kid mischief. Left alone much of the time—during World War II, his mother worked the swing shift at Douglas Aircraft and his father worked the graveyard shift at the San Pedro shipyard—he had the freedom to let his imagination roam wild. Blowing things up was one diversion. He tinkered with small homemade explosive devices in a laboratory in his garage. With nitroglycerine obtained from a friend's sister who worked at a chemical factory, he made pipe bombs to blow holes in the Palos Verdes wilderness. In his more sedate moments, he operated a ham radio and played chess with distant opponents over the airwaves.

He and a friend once dropped red dye into the Plunge at Long Beach, then California's largest indoor pool. Screaming swimmers fled the red blob, and the incident made the local paper. Another time, he attached an automobile headlight to a telescope and plugged it into a car battery. He hauled the contraption to a lovers' lane about a half mile from his home and waited for cars to line up. As car windows began to fog, he hit a button and lit up the parked assemblage like a cop with a spotlight, laughing as frantic teens panicked and sped away.

During high school, Thorp started thinking about gambling. One of his favorite teachers returned from a trip to Las Vegas full of cautionary tales about how one player after another got taken to the cleaners at the roulette table. "You just can't beat these guys," the teacher said. Thorp wasn't so sure. Around town, there were a number of illegal slot machines that would spit out a stream of coins if the handle was jiggled in just the right way. Roulette might have a similar hidden weakness, he thought, a *statistical* weakness.

Thorp was still thinking about roulette in his second year of graduate school physics at UCLA, in the spring of 1955. He wondered if he could discover a mathematical system to consistently win at roulette. Already he was thinking about how to use mathematics to describe

the hidden architecture of seemingly random systems—an approach he one day would wield on the stock market and develop into a theory that lies at the heart of quant investing.

One possibility was to find a roulette wheel with some kind of defect. In 1949, two roommates at the University of Chicago, Albert Hibbs and Roy Walford, found defects in a number of roulette wheels in Las Vegas and Reno and made several thousand dollars. Their exploits had been written up in *Life* magazine. Hibbs and Walford had been undergraduate students at the California Institute of Technology in Pasadena, and their accomplishments were well known to astute denizens of Caltech's neighbor, UCLA.

Thorp believed it was possible to beat roulette even without help from flaws in the wheel. Indeed, the absence of defects made it easier, since the ball would be traveling along a predictable path, like a planet in orbit. The key: because croupiers take bets after the ball is set in motion, it is theoretically possible to determine the position and velocity of the ball and rotor, and to predict approximately which pocket the ball will fall into.

The human eye, of course, can't accomplish such a feat. Thorp dreamed of a wearable computer that could track the motion of ball and wheel and spit out a prediction of where it would land. He believed he could create a machine that would statistically forecast the seemingly random motion of a roulette wheel: an observer would don the computer and feed in information about the speed of the wheel; a bettor, some distance away, would receive information via a radio link.

Thorp purchased a cheap half-scale wheel and filmed it in action, timing the motion with a stopwatch that measured in splits of hundredths of a second. Thorp soon realized that his cheap wheel was too riddled with flaws to develop a predictive system. Disappointed, he tabled the idea as he worked to finish graduate school. But it gnawed at him, and he continued to fiddle with experiments.

One evening, his in-laws visited him and his wife, Vivian, for dinner. They were surprised when Thorp didn't greet them at the door and wondered what he was up to. They found him in the kitchen rolling marbles down a V-shaped trough and marking how far the marbles spun across the kitchen floor before stopping. Thorp explained that he

was simulating the path of an orbiting roulette ball. Surprisingly, they didn't think their daughter had married a lunatic.

The Thorps made their first visit to Las Vegas in 1958, after Thorp had finished his degree and begun teaching. The frugal professor had heard that the rooms were cheap, and he was still toying with the idea of beating roulette. The smoothness of the wheels in Las Vegas convinced Thorp that he could predict the outcome. Now he just needed a solid, regulation-size wheel and suitable laboratory equipment.

Thorp had also decided to try out a blackjack strategy he'd recently come across. The strategy was from a ten-page article in the *Journal of the American Statistical Association* by U.S. Army mathematician Roger Baldwin and three of his colleagues—James McDermott, Herbert Maisel, and Wilbert Cantey—who'd been working at the Aberdeen Proving Ground, a military facility in Maryland. Among blackjack aficionados, Baldwin's group came to be known as the "Four Horsemen," although no one in the group actually tested the strategy in Las Vegas. Over the course of eighteen months, the Four Horsemen punched a massive amount of data into desktop calculators, plotting the probabilities involved in thousands of different hands of blackjack.

Ever the scientist, Thorp decided to give Baldwin's strategy a whirl in Las Vegas. While the test proved inconclusive (he lost a grand total of $8.50), he remained convinced the strategy could be improved. He contacted Baldwin and requested the data behind the strategy. It arrived in the spring of 1959, just before Thorp moved from UCLA to the Massachusetts Institute of Technology.

At MIT, Thorp found a hotbed of intellectual creativity that was quietly revolutionizing modern society. The job he stepped into, the coveted position of C. L. E. Moore Instructor, had previously been held by John Nash, the math prodigy who eventually won the Nobel Prize in economics in 1994 for his work on game theory, a mathematical approach to how people compete and cooperate. (Nash later became known as the subject of *A Beautiful Mind*, the book and movie about the competing forces of his genius and mental illness.)

That first summer in Cambridge, Thorp crunched the numbers on blackjack, slowly evolving what would become a historic break-

through in the game. He fed reams of unwieldy data into a computer, seeking hidden patterns that he could exploit for a profit. By the fall, he'd discovered the rudimentary elements of a blackjack system that could beat the dealer.

Eager to publish his results, he decided on a prestigious industry journal, *The Proceedings of the National Academy of Sciences*. The trouble: the journal accepted papers only from members of the academy. So he sought out the only mathematics member of the academy at MIT, Dr. Claude Elwood Shannon, one of the most brilliant, and eccentric, minds on the planet.

On a November afternoon in 1960, Ed Thorp walked briskly across MIT's leaf-strewn campus. A cold wind whistled off the Charles River. The freshly minted mathematics professor shuddered, and his nerves jangled at the very thought of sitting down face-to-face with Claude Shannon.

Few figures at MIT were more intimidating. Shannon was the brains behind two of the twentieth century's greatest intellectual advances. The first was the application of the binary number system to electronic circuits, which laid the groundwork for the birth of the computer. Shannon's great breakthrough had been to take a two-symbol logic in which problems are resolved by the manipulation of two numbers, 1 and 0, and apply it to a circuit in which a 1 is represented by a switch that is turned on and a 0 by a switch that is turned off. Sequences of on and off switches—essentially strings of 1s and 0s—could represent nearly any kind of information.

Shannon was also a founding father of information theory: how to encode information and transmit it from point A to point B. Crucially, and controversially, Shannon asserted at the start that while messages "frequently have meaning . . . [such] semantic aspects of communication are irrelevant to the engineering problem." In other words, information, as a technical matter, is completely devoid of meaning and context. Instead, it is purely statistical, and therefore encodable.

This was highly counterintuitive. Most scientists prior to Shannon

had assumed that the fundamental element of communication was meaning, and nothing but meaning. Shannon changed all that.

Thorp didn't want to talk to Shannon about the binary code or information theory, however. He wanted to talk about blackjack. He was still on edge as he stepped into Shannon's office. Shannon's secretary had warned him that the busy professor had only a few minutes to spare.

Thorp spat out his blackjack results as quickly as he could and showed Shannon his paper. Shannon was impressed and said that Thorp had made a significant theoretical breakthrough. He agreed to submit the paper, which was called "A Winning Strategy for Blackjack." But he had one suggestion.

"I think you might want to change the title."

"Okay," Thorp said, confused. "Why?"

"The Academy can be a bit stodgy. And this title has a bit too much of a whiff of the casino. How about 'A Favorable Strategy for Twenty-One'? That should be boring enough to pass the smell test."

Thorp agreed, and his few minutes were up. As he stood, Shannon asked, "Are you working on anything else in the gambling area?"

Thorp paused. He'd kept his roulette research largely secret, and he hadn't worked on it for months. But maybe Shannon would find it interesting.

"I've been conducting some studies of the game of roulette," he said, "and have had some . . . interesting results."

"Really?" Shannon said, his eyes lighting up. He gestured for Thorp to sit down again. "Continue."

Several hours later, Thorp left Shannon's office into the darkening November night.

Thorp started paying regular visits to Shannon's home later that November as the two scientists set to work on the roulette problem. Shannon called his home "Entropy House," a nod to a core concept in information theory, borrowed from the second law of thermodynamics. The law of entropy essentially means everything in the universe will eventually turn into a homogenous, undifferentiated goop. In

information theory, Shannon used entropy as a way to discover order within the apparent chaos of strings of seemingly random numbers.

Shannon's three-story wooden house overlooked the Mystic Lakes, several miles northwest of Cambridge. One look indoors told Thorp why Shannon likened it to a theory about the inexorable slide of the universe into utter randomness. It was a disorderly "gadgeteer's paradise," as Thorp later described it, packed with electronic and mechanical contraptions. Shannon was obsessed with automatons, machines that mimic human behavior, and he was especially fond of creating mechanical juggling dolls and coin tossers. He was a notorious unicyclist and impressed visitors by navigating a long tightrope stretched across his yard. One visitor was astounded by Shannon's daughter, who could ride a unicycle and skip rope at the same time. Shannon for a time was obsessed with trying to calculate how small one could make a unicycle and still ride it.

Science fiction writer Arthur C. Clarke visited Shannon's house a number of times. A device Shannon called the "ultimate machine" left him unnerved. "Nothing could be simpler," Clarke later wrote. "It is merely a small wooden casket, the size and shape of a cigar box, with a single switch on one face. When you throw the switch, there is an angry, purposeful buzzing. The lid slowly rises, and from beneath it emerges a hand. The hand reaches down, turns the switch off and retreats into the box. With the finality of a closing coffin, the lid snaps shut, the buzzing ceases and peace reigns once more. The psychological effect, if you do not know what to expect, is devastating. There is something unspeakably sinister about a machine that does nothing—absolutely nothing—except switch itself off."

Thorp and Shannon ordered a regulation roulette wheel from Reno for $1,500 and put it on a dusty slate billiard table. To parse its motion, they clocked it to the hypnotic pulse of a flashing strobe light. To time the ball, they would depress a switch each time it made one revolution around the wheel. The switch also triggered the strobe, marking where the ball stood at the moment the switch was hit. This let Thorp and Shannon gauge how well they were timing the ball, since it showed them how early or late they were in hitting the switch.

The results were ingenious, and perhaps doomed to fail. After much trial and error, Thorp and Shannon calculated a method to predict, with favorable odds, which octant of the roulette wheel the ball would tumble into. The wheel contained eight octants—six octants with five pockets each and two with four, making up the thirty-eight pockets on the wheel. If they could predict the octant, that tipped the odds sharply in their favor. If they bet on all four or five numbers in the predicted octant and their method proved accurate, winning would be guaranteed. It would be cheating, of course, and if they were caught, there was a predictably high chance that large, thick-necked casino bouncers with hairy knuckles would exact a price. But that was a concern for another day.

Thorp and Shannon designed a computer the size of a cigarette pack and embedded it in a pair of shoes. It had two switches: one switch turned on the computer, and the other timed the spinning of the rotor (one toe click when the wheel started and another when it made a single revolution). The computer calculated the results and transmitted which octant to bet on in eight tones to another person wearing a primitive sort of headphone in one ear. In all probability it was the world's first wearable computer.

However, technical problems doomed the project. The headphone wires often broke. One time Thorp, who generally wore the headphone and placed the bets, noticed a woman staring at him with horror. He promptly headed for the bathroom. In a mirror he saw the speaker jutting from his ear like an alien insect.

Though Shannon didn't lead Thorp to riches at the roulette wheel, the professor did make a key contribution to his younger colleague's blackjack strategy. While Thorp had devised a winning approach to blackjack, a key unanswered question remained: how much should a bettor wager if he doesn't want to risk financial ruin? Shannon told Thorp that the answer could be found in a 1956 paper by John Kelly Jr., a physics researcher at Bell Laboratories in Murray Hill, New Jersey. The paper described how much a gambler with inside information about the winner of a series of baseball games between two equally matched teams should wager if there is a certain

amount of noise (and hence a possibility that the information could be faulty) in the channel communicating that information.

Thorp realized he could use Kelly's betting system to optimally regulate how much he wagered on various scenarios in blackjack. In simplest terms, when his odds of winning rose, he tossed more chips on the table. When his odds got worse, he backed off.

A good way to size up Kelly's system is by comparison with another gambling strategy: doubling down. Say you bet $10 on a hand of blackjack and you lose. If you bet $20 on the next hand and win, you're up again. But you could lose that, of course. Bet $40, win, and you're back ahead. Doubling down, also known as martingale betting, has been a time-honored strategy practiced by gambling legends such as Casanova. But there's an obvious flaw in the strategy: gambler's ruin. Eventually the martingale gambler will run out of money. The odds of this happening, if the gambler keeps playing, are 100 percent.

Kelly, however, limited the amount from a player's billfold that could be placed on any bet. The only time a player would go all in would be when the odds of winning are 100 percent, a very rare event that almost never happens in a casino—although Thorp would discover such opportunities on Wall Street several years later.

The mathematics of Kelly told him exactly how much to add or subtract, based on the amount in his billfold, in order to achieve the maximum gains. The formula described, in the words of Kelly, how a gambler could "cause his money to grow exponentially," while at the same time avoiding the curse of gambler's ruin.

In January 1961, Thorp presented his blackjack paper to the American Mathematical Society. Since the AMS wasn't as conservative as the National Academy, which had already received the paper, Thorp provocatively titled it "Fortune's Formula: A Winning Strategy for Blackjack." A reporter for the Associated Press picked up on the paper and wrote a story about a brilliant math professor who'd cracked blackjack. The story appeared in newspapers nationwide. Suddenly Ed Thorp was famous.

The article also caught the eye of a number of enterprising

gamblers always on the make for a new system. Thorp fielded a flood of requests about the nature of his system, as well as offers to back him. One of the most generous came from a New York businessman who promised to pony up $100,000. Thorp was eager to test his theory, but he didn't think he needed that much cash. He decided to accept $10,000 and promptly headed for Reno.

The same day Thorp beat the dealer in that ratty Reno casino at five in the morning, he awoke in the afternoon eager to continue his experiment. After a hearty meal, he met with one of his financial backers, known as the mysterious "Mr. X" in the book he would later write detailing his system, *Beat the Dealer*. Later that day, a "Mr. Y" arrived.

Mr. X was, in fact, a New York businessman with connections to organized crime. His name was Emmanuel "Manny" Kimmel, a short, white-haired racketeer with his fingers in everything from numbers games in Newark, New Jersey, to East Coast horse tracks. He was also part owner of a company called Kinney Parking, which owned sixty-four parking lots in New York City. A 1965 FBI memo on Kimmel said he was "a lifetime associate of several internationally known hoodlums." Mr. Y was Eddie Hand, a car-shipping magnate and Kimmel's regular high-stakes gambling pal.

After Hand arrived, they went to Harold's Club, a famous casino located in an enormous building in the center of downtown Reno. It was a significant step up from the second-rate casino Thorp had played in the night before, and it would represent an even more rigorous test of his system.

They sat down at the $500-maximum tables, the highest amount possible. Within fifteen minutes they'd won $500, playing hands ranging from $25 to $250.

The dealer hit a concealed button with her foot. Thorp watched as the casino's owner, Harold Smith, marched toward them across the casino's floor.

"Good evening, gentlemen," Smith said, all smiles and glad-handing. Thorp wasn't fooled for a second. *He's out to stop me*.

After a few more hands, the deck had about fifteen cards left. Typically, dealers play out a deck until only a few cards are left. One way to trip up card counters is to shuffle the deck early.

"Shuffle," Smith said to the dealer. With the newly shuffled deck, Thorp and Kimmel kept winning, since the tens strategy can start paying off after only four cards are dealt, though the odds remain relatively slim, mandating careful bets. As the next deck was about halfway through, Smith nodded at the dealer.

"Shuffle."

Thorp's system still kept picking up favorable odds after several hands. The dealer started shuffling after dealing only two hands. While the system still worked, the repeated shuffling significantly curbed favorable opportunities. Thorp and Kimmel finally left, but they'd already pocketed several thousand dollars.

The combination of Thorp's winning blackjack model and Kelly's optimal betting system was powerful. Thorp and Kimmel continued to beat the dealer, despite a number of hurdles thrown their way. After several days, they had more than doubled their initial $10,000 stake.

Soon after Thorp announced his results in Washington, D.C., he was watching a TV program about gambling. A reporter asked a casino owner whether gambling ever paid off.

"When a lamb goes to the slaughter, the lamb might kill the butcher," the owner said. "But we always bet on the butcher."

Thorp smiled. He knew that he'd beaten the butcher. As he would later write: "The day of the lamb had come."

After his first excursion to Vegas, Thorp began work on *Beat the Dealer*. Published in 1962, the book quickly became a *New York Times* bestseller—and struck terror into the heart of casino bigwigs everywhere.

Thorp continued to rack up gains at blackjack tables on several return trips to Las Vegas. Dealers were on the lookout for the gambling professor. He began wearing disguises, well aware of stories about card counters getting hauled into side alleys or casino basements for brutal beatings.

One day in 1964, when he was playing at a baccarat table in Las Vegas, he was offered a cup of coffee with cream and sugar. He took a few sips, then started feeling odd.

A friend who'd traveled to Las Vegas with Thorp and his wife

happened to be a nurse. She peered into his eyes and recognized the look of drugged-out patients who landed in the emergency room. He walked it off, but the episode unnerved him. He decided he needed to find a fresh venue to test his strategies.

Thorp immediately set his sights on the biggest casino of all: Wall Street.

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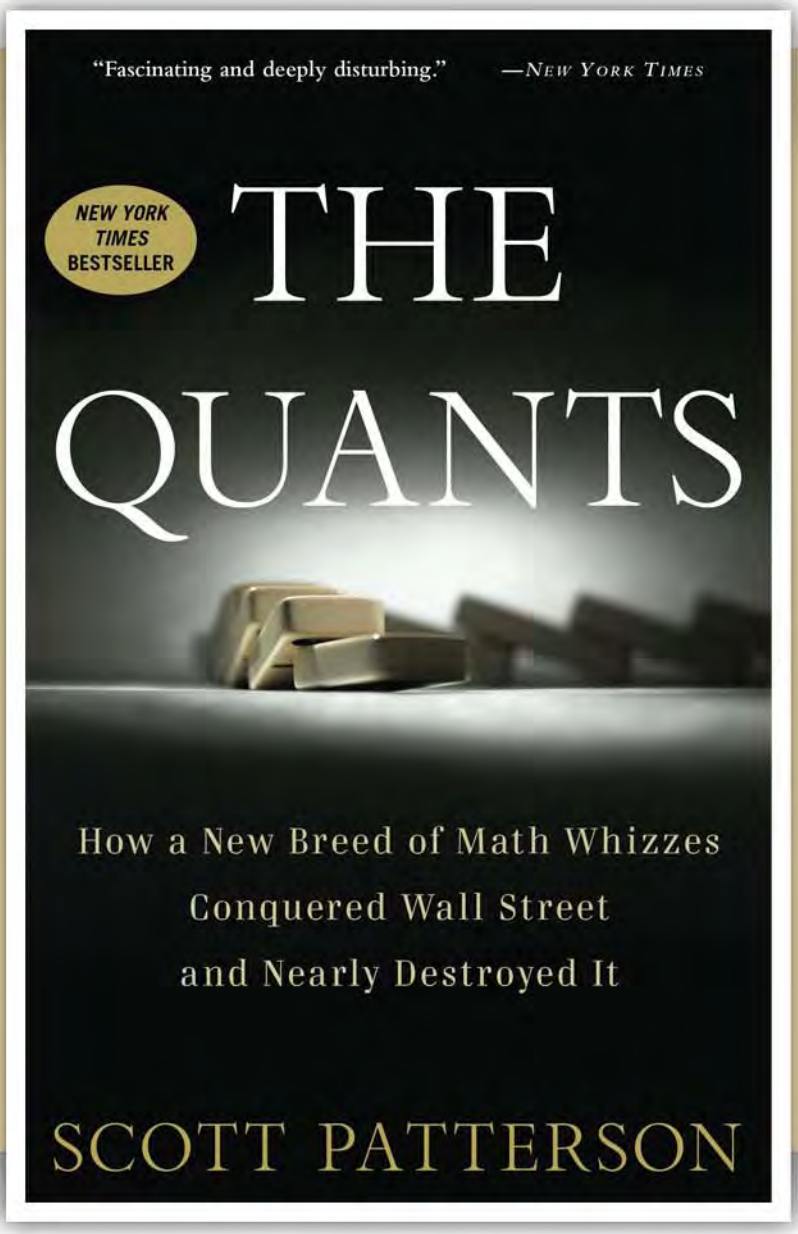

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