# Inside a Moneymaking Machine Like No Other

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More

**Sixty miles east** of Wall Street, a spit of land shaped like a whale's tail separates Long Island Sound and Conscience Bay. The mansions here, with their long, gated driveways and million-dollar views, are part of a hamlet called Old Field. Locals have another name for these moneyed lanes: the Renaissance Riviera.

That's because the area's wealthiest residents, scientists all, work for the quantitative hedge fund Renaissance Technologies, based in nearby East Setauket. They are the creators and overseers of the Medallion Fund—perhaps the world's greatest moneymaking machine. Medallion is open only to Renaissance's roughly 300 employees, about 90 of whom are Ph.D.s, as well as a select few individuals with deep-rooted connections to the firm.

The fabled fund, known for its intense secrecy, has produced about $55 billion in profit over the last 28 years, according to data compiled by Bloomberg, making it about $10 billion more profitable than funds run by billionaires Ray Dalio and George Soros. What's more, it did so in a shorter time and with fewer assets under management. The fund almost never loses money. Its biggest drawdown in one five-year period was half a percent.

"Renaissance is the commercial version of the Manhattan Project," says Andrew Lo, a finance professor at MIT's Sloan School of Management and chairman of AlphaSimplex, a quant research firm. Lo credits Jim Simons, the 78-year-old mathematician who founded Renaissance in 1982, for bringing so many scientists together. "They are the pinnacle of quant investing. No one else is even close."

Few firms are the subject of so much fascination, rumor, or speculation. Everyone has heard of Renaissance; almost no one knows what goes on inside. (The company also operates three hedge funds, open to outside investors, that together oversee about $26 billion, although their performance is less spectacular than Medallion's.) Apart from Simons, who retired in 2009 to focus on philanthropic causes, relatively little has been known about this small group of scientists—whose vast wealth is greater than the gross domestic product of many countries and increasingly influences U.S. politics—until now. Renaissance's owners and executives declined to comment for this story through the company's spokesman, Jonathan Gasthalter. What follows is the product of extensive research and more than two dozen interviews with people who know them, have worked with them, or have competed against them.

Renaissance is unique, even among hedge funds, for the genius—and eccentricities—of its people. Peter Brown, who co-heads the firm, usually sleeps on a Murphy bed in his office. His counterpart, Robert Mercer, rarely speaks; you're more likely to catch him whistling *Yankee Doodle Dandy* in meetings than to hear his voice. Screaming battles seem to help a pair of identical twins, both of them Ph.D. string theorists, produce some of their best work. Employees aren't above turf wars, either: A power grab may have once lifted a Russian scientist into a larger role within the highly profitable equity business in a new guard vs. old guard struggle.

For outsiders, the mystery of mysteries is how Medallion has managed to pump out annualized returns of almost 80 percent a year, before fees. "Even after all these years they've managed to fend off copycats," says Philippe Bonnefoy, a former Medallion investor who later co-founded Eleuthera Capital, a Switzerland-based quantitative macro firm. Competitors have identified some likely reasons for the fund's success, though. Renaissance's computers are some of the world's most powerful, for one. Its employees have more—and better—data. They've found more signals on which to base their predictions and have better models for allocating capital. They also pay close attention to the cost of trades and to how their own trading moves the markets.

But as computing power becomes ever cheaper and competitors sharpen their skills, will Medallion continue to mint money?

Quants seem like saviors to investors disappointed with how mere mortals have managed their money of late. In 2016 clients plugged $21 billion into quant hedge funds, while pulling $60 billion from those that do everything else. One noteworthy quant shop, Two Sigma, managed just $5 billion during the financial crisis and has seen assets jump to $37 billion. Even old-fashioned traders such as Paul Tudor Jones and Steve Cohen are adding to their computer scientist ranks in hopes of boosting returns.

Renaissance's success, of course, ultimately lies with the people who built, improved upon, and maintain Medallion's models, many of whom met at IBM in the 1980s, where they used statistical analysis to tackle daunting linguistic challenges. This is their story.

**Simons is already** well-known: math genius, professor at MIT and Harvard, recipient of the Oswald Veblen Prize in Geometry, and co-creator of the Chern-Simons theory. He

was also a code breaker for the Institute for Defense Analyses, where he worked finding messages amid the noise.

The goal of quant trading is similar: to build models that find signals hidden in the noise of the markets. Often they're just whispers, yet they'll help predict how the price of a stock or a bond or a barrel of oil might move. The problem is complex. Price movements depend on fundamentals and flows and the sometimes irrational behavior of people who are doing the buying and selling.

Although Simons lost the IDA job after denouncing the Vietnam War in a letter to the *New York Times*, the connections he made through his work in cryptography helped create Renaissance and, a few years later, Medallion. Over the next decade, while chairing the math department at Stony Brook University, Simons dabbled in trading commodity futures. In 1977 he left academia for good to try his hand at managing money.

Initially he bought and sold commodities, making his bets based on fundamentals such as supply and demand. He found the experience gut wrenching, so he turned to his network of cryptographers and mathematicians for help looking at patterns: Elwyn Berlekamp and Leonard Baum, former colleagues from IDA, and Stony Brook professors Henry Laufer and James Ax. "Maybe there were some ways to predict prices statistically," Simons said in a 2015 interview with Numberphile. "Gradually we built models."

At their core, such models usually fall into one of two camps, trend-following or mean-reversion. Renaissance's system had a foot in both. Its results were mixed at first: up 8.8 percent in 1988, its first year, and down 4.1 percent in 1989. But in 1990, after focusing exclusively on shorter-term trading, Medallion chalked up a 56 percent return, net of fees. "I was confident that the models would work better," says Berlekamp, who returned to academia in 1991 and is now a professor emeritus at the University of California at Berkeley. "I didn't think they would be as good as they were."

Eventually the scientists went so far as to develop an in-house programming language for their models rather than settle for a numbercentric option such as ASCII, which was popular at the time. Today, Medallion uses dozens of "strategies" that run together as one system. The code powering the fund includes several million lines, according to people familiar with the company. Various teams are responsible for specific areas of research, but in practice everybody can work on everything. There's a meeting every Tuesday to hash out ideas.

**In the early 1990s,** big annual returns became the norm at Renaissance: 39.4 percent, 34 percent, 39.1 percent. Prospective investors clamored to get into Medallion, but the company didn't pay them much heed—or coddle clients for that matter. Bonnefoy recalls dialing a Manhattan phone number to hear a recording of the monthly returns; Renaissance's legal department doubled as unhelpful customer service representatives. (To this day the company's website, rentec.com, looks like it dates from the Netscape era.) In 1993, Renaissance stopped accepting new money from outsiders. Fees were also ratcheted up—from 5 percent of assets and 20 percent of profits, to 5 percent and 44 percent. "They raised their fees to exorbitant levels and were still head and shoulders

above everyone else," says Bonnefoy, who, along with every other outsider, was finally booted from Medallion in 2005.

Encouraged by Medallion's success, Simons by the mid-'90s was looking for more researchers. A résumé with Wall Street experience or even a finance background was a firm pass. "We hire people who have done good science," Simons once said. The next surge of talent—much of which remains the core of the company today—came from a team of mathematicians at the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., who were wrestling with speech recognition and machine translation.

In the early days of tackling these problems, computer scientists teamed with linguists and tried to code grammar. At IBM, a group including Mercer and Brown reasoned that the problems would be better solved using statistics and probabilities. (Their boss, Frederick Jelinek, liked to say, "Whenever I fire a linguist, the system gets better.") According to scientists who worked at the research center then, the team fed reams of data into its computers. Documents from the Canadian Parliament, for instance, were available in both English and French, which none of the scientists spoke. (Mercer once disappeared for several months to type French verb conjugations into a computer, according to a source.) The data allowed them to write an algorithm that found the most likely match for the phrase *Le chien est battu par Jean* was "John beat the dog." A similar approach applied to speech recognition: Given auditory signal $x$, the speaker probably said the word $y$.

"Speech recognition and translation are the intersection of math and computer science," says Ernie Chan, who worked at the research center in the mid-1990s and now runs quant firm QTS Capital Management. The scientists weren't just working on academic problems; they were also developing theories and writing software to implement the solutions, he says. The group's work eventually paved the way for Google Translate and Apple's Siri.

Mercer and Brown went to IBM's management in 1993 with a bold proposition, says a person who knows the two: Let them build models to manage a portion of the colossal company's then-$28 billion pension fund. IBM balked, questioning what computational linguists would know about overseeing investments. But the duo's fascination with financial markets was just beginning.

That same year, Nick Patterson, a former code breaker for British and U.S. intelligence agencies, joined Renaissance and approached acquaintances Brown and Mercer. "IBM was in serious trouble, and morale was poor, so it was something of a recruiting opportunity," says Patterson, who worked at Renaissance until 2001 and is now a senior computational biologist researching genetics at the Broad Institute of MIT and Harvard. The two decided to join, drawn by the 50 percent pay raise. They roomed in an attic apartment in Setauket and often dined together. When the bill came, they would pull out a special calculator that could generate random numbers. Whoever produced the higher number picked up the tab.

"Renaissance was started by a couple of mathematicians," Brown said in a 2013 conferencefor computational linguists. "They had no idea how to program. They're people who learned how to program by reading computer manuals, and that's not a particularly

good way of learning." He and Mercer had learned how to build large systems—with many people working on them simultaneously—which was a skill set they used to Renaissance's advantage. Not that their new field was without challenges. "It's all noise in finance," he said.

More IBM veterans joined them on Long Island, including Stephen and Vincent Della Pietra, the string-theorist twins; Lalit Bahl, who had created algorithms to recognize human speech; Mukund Padmanabhan, whose specialty was digital-signal processing; David Magerman, a programmer; and Glen Whitney, who wrote software as a summer intern. "The takeaway from IBM was that the whole is greater than the sum of its parts," says Chan. "They all worked together."

Renaissance also spent heavily collecting, sorting, and cleaning data, as well as making it accessible to its researchers. "If you have an idea, you want to test it quickly. And if you have to get the data in shape, it slows down the process tremendously," says Patterson.

Cerebral challenges weren't the only incentive for Renaissance's data-hungry scientists. They also enjoyed something more intangible: a sense of family.

**Simons was the** benevolent father figure. No other Renaissance senior executive has possessed his people skills, those who know him and the company say, and he inspired the supernerds to stick together. "It's an open atmosphere," Simons said in a speech at MIT in 2010. "We make sure everyone knows what everyone else is doing, the sooner the better. That's what stimulates people."

When the IBM crew arrived at Renaissance, Medallion was already producing annual returns, after fees, of at least 30 percent almost exclusively from futures trading. In the early days, anomalies were easy to spot and exploit. A Renaissance scientist noted that Standard & Poor's options and futures closing times were 15 minutes apart, a detail he turned into a profit engine for a time, one former investor says. The system was full of such aberrations, he says, and the scientists researched each of them to death. Adding them all up produced serious money—millions at first, and before long, billions.

But as financial sophistication grew and more quants plied their craft at decoding markets, the inefficiencies began disappearing. When Mercer and Brown joined they were assigned to different research areas, but it soon became apparent they were better together than apart. They fed off each other: Brown was the optimist, and Mercer the skeptic. "Peter is very creative with a lot of ideas, and Bob says, 'I think we need to think hard about that,' " says Patterson. They took charge of the equities group, which people say was losing money. "It took them four years to get the system working," says Patterson. "Jim was very patient." The investment paid off. Today the equities group accounts for the majority of Medallion's profits, primarily using derivatives and leverage of four to five times its capital, according to documents filed with the U.S. Department of Labor.

"You need to build a system that is layered and layered," Simons said in a 2000 interview with *Institutional Investor*, explaining some of the philosophy behind the firm and the Medallion model. "And with each new idea, you have to determine: Is this

really new, or is this somehow embedded in what we've done already?" Once that's determined, the team would figure out how much weighting to give it. Signals may eventually go cold over time but will usually be kept around because they can sometimes reemerge—or have unintended consequences if removed. A source says positions are held anywhere from seconds to seasons.

At the 2013 conference, Brown referenced an example they once shared with outside Medallion investors: By studying cloud cover data, they found a correlation between sunny days and rising markets from New York to Tokyo. "It turns out that when it's cloudy in Paris, the French market is less likely to go up than when it's sunny in Paris," he said. It wasn't a big moneymaker, though, because it was true only slightly more than 50 percent of the time. Brown continued: "The point is that, if there were signals that made a lot of sense that were very strong, they would have long ago been traded out. ... What we do is look for lots and lots, and we have, I don't know, like 90 Ph.D.s in math and physics, who just sit there looking for these signals all day long. We have 10,000 processors in there that are constantly grinding away looking for signals."

In addition to language specialists, astrophysicists have historically had an outsize impact on the system's success, according to people familiar with the firm. These scientists excel at screening "noisy" data. String theorists have also had a major role, and the Della Pietra brothers—who reunited with their former IBM bosses to work on equities—were the first of many with that background. The identical twins, now 56, have never strayed far from each other: They took an honors science program at Columbia University as high school students; attended Princeton as undergraduates, studying physics; and received doctorates from Harvard in 1986.

"They always sat next to each other," says Steven Strogatz, a math professor at Cornell University who remembers them as Princeton freshmen in a junior-year-level abstract algebra class. "Their talking involved a lot of arguing. It was passionate mathematical discussion, and they were always correcting the teacher or explaining something to each other." Chan, who worked with them at IBM, remembers them screaming at each other—but never at anyone else, to whom they were kind and humble. Their twinship added another dimension, too. "They are almost telepathic," he says.

At Renaissance, the Della Pietras have shared adjacent offices separated by an internal window to facilitate discussion. "They are creative people and very competitive with each other," says Patterson, to whom they reported for a time.

The IBM crew focused on improving the system's performance and efficiency. Since Renaissance's models were short-term oriented, they spent time looking at execution costs and researching how their trades moved the markets—a particularly difficult problem to crack, according to other quants. They also ensured that the trades and profits matched what the system had intended, since a bad price or other glitch could throw off the whole operation.

**How much money** an employee has in Medallion depends on his overall contribution to the firm—and collaboration is key to getting a bigger piece of the pie. Employees are

awarded an allocation of shares they can buy. In addition, a quarter of one's pay is deferred and invested in Medallion, where it stays for four years. Employees must also pay fees of as much as "5 and 44."

Simons determined, almost from the beginning, that the fund's overall size can affect performance: Too much money destroys returns. Renaissance currently caps Medallion's assets between $9 billion and $10 billion, about twice what it was a decade ago. Profits get distributed every six months.

Thanks to Medallion, Simons—who still owns as much as 50 percent of the firm—has a net worth of $15.5 billion, according to estimates by the Bloomberg Billionaires Index. Laufer, who owns the next-largest stake (possibly as much as 25 percent), Brown, and Mercer are among other employees worth hundreds of millions of dollars.

In some ways, money, not unlike the company's familial feel, even binds the place together. With the exception of the scientists who depart for academia or to pursue philanthropy, folks don't leave Renaissance. Why would they? The problems are complex, the colleagues first-rate, and the paychecks huge.

As everyone became rich off Medallion, lifestyles changed. Trains to Manhattan gave way to helicopter commutes. Scientists swapped Hondas for Porsches. Fancy hobbies became normal. Simons's cousin, Robert Lourie, who heads futures research, built an equestrian arena for his daughter, with arches so large that a bridge into New York City had to be shut down at night to facilitate their journey. Yachts also became a thing. Mercer has commissioned a succession of them, each called *Sea Owl*. For his part, Simons's 222-foot *Archimedes* has a wood-burning fireplace. Both vessels have a propulsion system so novel that they don't require an anchor. Always the merry ringleader, Simons planned company trips—to Bermuda, the Dominican Republic, Florida, Vermont—and encouraged employees to bring their families. Company lore is that on one of the firm's ski trips, Simons, a longtime smoker, bought an insurance policy for a restaurant so he wouldn't have to forgo his beloved Merits.

Money has also threatened to destroy the family atmosphere. In 2001, Renaissance hired a Russian scientist who, like many of his peers, came west after the collapse of the Soviet Union: Alexander Belopolsky. Patterson was against bringing him aboard, he says, because he had recently worked on Wall Street, where he had job-hopped. His fears proved prescient. In 2003 he and another Russian, Pavel Volfbeyn, announced they were leaving for hedge fund Millennium Partners, where they'd negotiated healthy bonuses and the right to keep a large part of their own profits. Renaissance sued them and Millennium, worried the researchers would take the firm's secrets with them. All parties later settled out of court.

Around that time another of Renaissance's Russian-born researchers, Alexey Kononenko, who received his Ph.D. from Penn State in 1997 and had also done a brief stint on Wall Street, was promoted within the equities group. Senior staffers ended up discussing Kononenko's advancement during one of their regular dinners at Simons's house. One person familiar with the situation says the scientists were just questioning why he had

moved ahead of colleagues who had been there much longer, much the way an academic might complain about a younger colleague getting tenure. Other people with knowledge of the firm say Kononenko's promotion was a significant event in Renaissance's history and that the Russian had actually executed a power play.

Whatever the reasons for Kononenko's advancement, the outcome has safeguarded the well from which Renaissance's wealth flows: Medallion has averaged more than a 40 percent return, after fees, since the dinner.

**When rivals and** former investors are asked how Renaissance can continue to make such mind-blowing returns, the response is unanimous: They run faster than anyone else. Yet all that running hasn't always kept them on their feet when everyone else stumbled.

In August 2007, rising mortgage defaults sent several of the largest quant hedge funds, including a $30 billion giant run by Goldman Sachs, into a tailspin. Managers at these firms were forced to cut positions, worsening the carnage. Insiders say the rout cost Medallion almost $1 billion—around one-fifth of the fund—in a matter of days. Renaissance executives, wary that continued chaos would wipe out their own fund, braced to turn down their own risk dial and begin selling positions. They were on the verge of capitulating when the market rebounded; over the remainder of the year, Medallion made up the losses and more, ending 2007 with an 85.9 percent gain. The Renaissance executives had learned an important lesson: Don't mess with the models.

Another lesson may one day prove even more important: Beware of the damage others can cause. In a letter that same month to investors in his public institutional equities fund, Simons wrote: "While we believe we have an excellent set of predictive signals, some of these are undoubtedly shared by a number of long/short hedge funds."

No system lasts forever, say quants. They ask how long Medallion's magic can continue. But seven years after Simons's retirement, the fund's money-printing ways persist. Even in the first half of 2016, while many hedge funds struggled, it made more than 20 percent. Wealth and influence at Renaissance have grown apace.

Yet as successful as Renaissance has been under Brown and Mercer—who are 61 and 70, respectively—industry insiders wonder how the firm will handle its next succession. They also reserve their reverence. Take, for instance, the anecdote from an invite-only conference earlier this year. An audience member asked a panel of quant managers, "Who would be your dream hire?" After a bit of nervous laughter, one of them gave his honest answer: Jim Simons.