INTRODUCTION

WINDOWS ON THE WORLD

I suppose this book started when I first heard the story of Sergey Aleynikov, the Russian computer programmer who had worked for Goldman Sachs and then, in the summer of 2009, after he'd quit his job, was arrested by the FBI and charged by the United States government with stealing Goldman Sachs's computer code. I'd thought it strange, after the financial crisis, in which Goldman had played such an important role, that the only Goldman Sachs employee who had been charged with any sort of crime was the employee who had taken something from Goldman Sachs. I'd thought it even stranger that government prosecutors had argued that the Russian shouldn't be freed on bail because the Goldman Sachs computer code, in the wrong hands, could be used to "manipulate markets in unfair ways." (Goldman's were the right hands? If Goldman Sachs was able to manipulate markets, could other banks do it, too?) But maybe the strangest aspect of the case was how difficult it appeared to be—for the few who attempted—to explain what the Russian

had done. I don't mean only what he had done wrong: I mean what he had done. His job. He was usually described as a "high-frequency trading programmer," but that wasn't an explanation. That was a term of art that, in the summer of 2009, most people, even on Wall Street, had never before heard. What was high-frequency trading? Why was the code that enabled Goldman Sachs to do it so important that, when it was discovered to have been copied by some employee, Goldman Sachs needed to call the FBI? If this code was at once so incredibly valuable and so dangerous to financial markets, how did a Russian who had worked for Goldman Sachs for a mere two years get his hands on it?

At some point I went looking for someone who might answer those questions. My search ended in a room looking out at the World Trade Center site, at One Liberty Plaza. In this room were gathered a small army of shockingly well-informed people from every corner of Wall Street—big banks, the major stock exchanges, and high-frequency trading firms. Many of them had left high-paying jobs to declare war on Wall Street, which meant, among other things, attacking the very problem that the Russian computer programmer had been hired by Goldman Sachs to create. In the bargain they'd become experts on the questions I sought answers to, along with a lot of other questions I hadn't thought to ask. These, it turned out, were far more interesting than I expected them to be.

I didn't start out with much interest in the stock market—though, like most people, I enjoy watching it go boom and crash. When it crashed on October 19, 1987, I happened to be hovering around the fortieth floor of One New York Plaza, the stock market trading and sales department of my then employer, Salomon Brothers. *That* was interesting. If you ever needed proof that even

Wall Street insiders have no idea what's going to happen next on Wall Street, there it was. One moment all is well; the next, the value of the entire U.S. stock market has fallen 22.61 percent, and no one knows why. During the crash, some Wall Street brokers, to avoid the orders their customers wanted to place to sell stocks, simply declined to pick up their phones. It wasn't the first time that Wall Street people had discredited themselves, but this time the authorities responded by changing the rules—making it easier for computers to do the jobs done by those imperfect people. The 1987 stock market crash set in motion a process—weak at first, stronger over the years—that has ended with computers entirely replacing the people.

Over the past decade, the financial markets have changed too rapidly for our mental picture of them to remain true to life. The picture I'll bet most people have of the markets is still a picture a human being might have taken. In it, a ticker tape runs across the bottom of some cable TV screen, and alpha males in color-coded jackets stand in trading pits, hollering at each other. That picture is dated; the world it depicts is dead. Since about 2007, there have been no thick-necked guys in color-coded jackets standing in trading pits; or, if they are, they're pointless. There are still some human beings working on the floor of the New York Stock Exchange and the various Chicago exchanges, but they no longer preside over any financial market or have a privileged view inside those markets. The U.S. stock market now trades inside black boxes, in heavily guarded buildings in New Jersey and Chicago. What goes on inside those black boxes is hard to say—the ticker tape that runs across the bottom of cable TV screens captures only the tiniest fraction of what occurs in the stock markets. The public reports of what happens inside the black boxes are fuzzy and unreliable—even an expert cannot say what exactly happens

inside them, or when it happens, or why. The average investor has no hope of knowing, of course, even the little he needs to know. He logs onto his TD Ameritrade or E*Trade or Schwab account, enters a ticker symbol of some stock, and clicks an icon that says "Buy": Then what? He may think he knows what happens after he presses the key on his computer keyboard, but, trust me, he does not. If he did, he'd think twice before he pressed it.

The world clings to its old mental picture of the stock market because it's comforting; because it's so hard to draw a picture of what has replaced it; and because the few people able to draw it for you have no interest in doing so. This book is an attempt to draw that picture. The picture is built up from a bunch of smaller pictures—of post-crisis Wall Street; of new kinds of financial cleverness; of computers, programmed to behave impersonally in ways that the programmer himself would never do personally; of people, coming to Wall Street with one idea of what makes the place tick only to find that it ticks rather differently than they had supposed. One of these people—a Canadian, of all things—stands at the picture's center, organizing the many smaller pictures into a coherent whole. His willingness to throw open a window on the American financial world, and to show people what it has become, still takes my breath away.

As does the Goldman high-frequency trading programmer arrested for stealing Goldman's computer code. When he worked for Goldman Sachs, Sergey Aleynikov had a desk on the forty-second floor of One New York Plaza, the site of the old Salomon Brothers trading floor, two floors above the place I'd once watched the stock market crash. He hadn't been any more interested in staying in that building than I had been and, in the summer of 2009, had left to seek his fortune elsewhere. On July 3, 2009, he was on a flight from Chicago to Newark, New Jersey, blissfully

unaware of his place in the world. He had no way of knowing what was about to happen to him when he landed. Then again, he had no idea how high the stakes had become in the financial game he'd been helping Goldman Sachs to play. Oddly enough, to see the magnitude of those stakes, he had only to look out the window of his airplane, down on the American landscape below.

CHAPTER ONE

HIDDEN IN PLAIN SIGHT

By the summer of 2009 the line had a life of its own, and two thousand men were digging and boring the strange home it needed to survive. Two hundred and five crews of eight men each, plus assorted advisors and inspectors, were now rising early to figure out how to blast a hole through some innocent mountain, or tunnel under some riverbed, or dig a trench beside a country road that lacked a roadside—all without ever answering the obvious question: *Why?* The line was just a one-and-a-half-inch-wide hard black plastic tube designed to shelter four hundred hair-thin strands of glass, but it already had the feeling of a living creature, a subterranean reptile, with its peculiar needs and wants. It needed its burrow to be straight, maybe the most insistently straight path ever dug into the earth. It needed to connect a data center on the South Side of Chicago* to a stock exchange in northern New Jersey. Above all, apparently, it needed to be a secret.

* The principal data center was later moved to Aurora, Illinois, outside Chicago.

The workers were told only what they needed to know. They tunneled in small groups apart from each other, with only a local sense of where the line was coming from or where it was going to. They were specifically not told of the line's purpose—to make sure they didn't reveal that purpose to others. "All the time, people are asking us, 'Is this top secret? Is it the government?' I just said, 'Yeah,' " said one worker. The workers might not have known what the line was for, but they knew that it had enemies: They all knew to be alert to potential threats. If they saw anyone digging near the line, for instance, or noticed anyone asking a lot of questions about it, they were to report what they'd seen immediately to the head office. Otherwise they were to say as little as possible. If people asked them what they were doing, they were to say, "Just laying fiber." That usually ended the conversation, but if it didn't, it didn't really matter. The construction crews were as bewildered as anyone. They were used to digging tunnels that connected cities to other cities, and people to other people. This line didn't connect anyone to anyone else. Its sole purpose, as far as they could see, was to be as straight as possible, even if that meant they had to rocksaw through a mountain rather than take the obvious way around it. *Why?*

Right up until the end, most workers didn't even ask the question. The country was flirting with another depression and they were just happy for the work. As Dan Spivey said, "No one knew why. People began to make their reasons up."

Spivey was the closest thing the workers had to an explanation for the line, or the bed they were digging for it. And Spivey was by nature tight-lipped, one of those circumspect southerners with more thoughts than he cared to share. He'd been born and raised in Jackson, Mississippi, and, on those rare occasions he spoke, he sounded as if he'd never left. He'd just turned forty but was still as

lean as a teenager, with the face of a Walker Evans tenant farmer. After some unsatisfying years working as a stockbroker in Jackson he'd quit, as he put it, "to do something more sporting." That turned out to be renting a seat on the Chicago Board Options Exchange and making markets for his own account. Like every other trader on the Chicago exchanges, he saw how much money could be made trading futures contracts in Chicago against the present prices of the individual stocks trading in New York and New Jersey. Every day there were thousands of moments when the prices were out of whack—when, for instance you could sell the futures contract for more than the price of the stocks that comprised it. To capture the profits, you had to be fast to both markets at once. What was meant by "fast" was changing rapidly. In the old days—before, say, 2007—the speed with which a trader could execute had human limits. Human beings worked on the floors of the exchanges, and if you wanted to buy or sell anything you had to pass through them. The exchanges, by 2007, were simply stacks of computers in data centers. The speed with which trades occurred on them was no longer constrained by people. The only constraint was how fast an electronic signal could travel between Chicago and New York—or, more precisely, between the data center in Chicago that housed the Chicago Mercantile Exchange and a data center beside the Nasdaq's stock exchange in Carteret, New Jersey.

What Spivey had realized, by 2008, was that there was a big difference between the trading speed that was available between these exchanges and the trading speed that was theoretically possible. Given the speed of light in fiber, it should have been possible for a trader who needed to trade in both places at once to send his order from Chicago to New York and back in roughly 12 milliseconds, or roughly a tenth of the time it takes you to

blink your eyes, if you blink as fast as you can. (A millisecond is one thousandth of a second.) The routes offered by the various telecom carriers—Verizon, AT&T, Level 3, and so on—were slower than that, and inconsistent. One day it took them 17 milliseconds to send an order to both data centers; the next, it took them 16 milliseconds. By accident, some traders had stumbled across a route controlled by Verizon that took 14.65 milliseconds. "The Gold Route," the traders called it, because on the occasions you happened to find yourself on it you were the first to exploit the discrepancies between prices in Chicago and prices in New York. Incredibly to Spivey, the telecom carriers were not set up to understand the new demand for speed. Not only did Verizon fail to see that it could sell its special route to traders for a fortune; Verizon didn't even seem aware it owned anything of special value. "You would have to order up several lines and hope that you got it," says Spivey. "They didn't know what they had." As late as 2008, major telecom carriers were unaware that the financial markets had changed, radically, the value of a millisecond.

Upon closer investigation, Spivey saw why. He went to Washington, DC, and got his hands on the maps of the existing fiber cable routes running from Chicago to New York. They mostly followed the railroads and traveled from big city to big city. Leaving New York and Chicago, they ran fairly straight toward each other, but when they reached Pennsylvania they began to wiggle and bend. Spivey studied a map of Pennsylvania and saw the main problem: the Allegheny Mountains. The only straight line running through the Alleghenies was the interstate highway, and there was a law against laying fiber along the interstate highway. The other roads and railroads zigzagged across the state as the landscape permitted. Spivey found a more detailed map of Pennsylvania and drew his own line across it. "The straightest