

(chapters written by Bradford Tuckfield in May 2022)

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Introduction: Crackpots and What We Can Learn from Them

In 1997, Tom Zhang was working at a Subway sandwich shop in Kentucky. He was 42 years old, and for nearly all of his life, he had been an outsider. When he was a child in China, his family had been on the wrong side of local politics, and he and his mother were forced to spend 10 years in a labor camp. Working as a forced laborer for ten years, Tom was kept on the outside of high school and the normal life every child wants. Later, he studied math in college, and was gifted enough to get a full scholarship to a PhD program at Purdue. But even in his PhD program, he wasn't able to shake his outsider status. His own advisor had bitter disputes with him, didn't help him get a job after graduation, and later said that Tom wasted 7 years of both of their lives during his PhD studies.

After graduating from Purdue, Tom reached the lowest point of his life. Since college, he had dreamed of being a great mathematician. But he had not yet published a single research paper in an academic math journal. For eight years after getting his doctorate, his lack of publications meant that he was unable to find a job as a mathematician anywhere. He lived in his car for a while, and worked odd jobs, at one point delivering food in New York, and at another point doing part-time accounting work for a motel. He never made much money in these jobs, and never felt like he was anywhere near achieving his dream of being a great mathematician. He was firmly outside of the scientific world that he longed to enter.

Today, Tom is recognized as one of the greatest living mathematicians in the world. But in 1997, neither he nor anyone else knew that that's what his future held. Take a moment to imagine what it would have been like to meet Tom at that time. What would it be like to walk into the Subway sandwich shop where he worked? You might start a conversation with him and find out what his hobbies were. He would tell you that he was interested in math, and he was thinking about some new ideas related to the Riemann Hypothesis. If you know much about math, you'll know that the Riemann Hypothesis is one of the most important math problems of the last two centuries. Whoever proves this hypothesis is entitled to a million-dollar prize offered by a math foundation, and they'll certainly get fame in the mathematical world and career rewards as well. If you met a 42-year old man of humble origins who had never published a math paper, who worked at Subway, and who thought he had a chance of publishing a groundbreaking paper about this topic, what would you think?

You might think that Tom was a crackpot. You might think that if he was ever going to find success as a mathematician, he should have found it already by age 42. After all, the great mathematician G.H. Hardy described math as a "young man's game," writing that he was not aware of any major mathematical advance initiated by a man past fifty. You might think that Tom was just deceiving himself, dreaming an impossible dream, lacking the talent or insight to truly succeed. You might predict that he would be working at Subway for the rest of his life. Of course, there's nothing wrong with working at a

sandwich shop: all honest work is honorable. But this job was not Tom's dream. He wanted to contribute to the top level of science. So far, there were no signs that he ever would, since he had always been an outsider.

But at age 42, Tom was nearly at the end of his worst years. Within a year, he had started applying to teaching jobs. Two years later, in 1999, he was offered a job as a lecturer in the math department at the University of New Hampshire. This was a step closer to achieving his dream. Finally he was back in the world of academic math, using the skills and knowledge he had gained during his doctoral studies. But he was still far from the center of the mathematical world. He was just a lecturer, not a full professor or even an assistant professor, and he was at a university whose prestige was relatively low. Besides that, he still hadn't published a single research paper in his entire life. Even after getting this lecturer job, he must have felt like he was still an outsider.

Two years after getting the lecturer job, Tom published his first math research paper, about some ideas related to the Riemann Hypothesis that he had been thinking about when he had worked at Subway. This was another great milestone for Tom. The paper was published in the *Duke Mathematical Journal*, a respected academic research journal. Its impact on the world of math can be measured by the fact that it has been cited by other professional mathematicians dozens of times.

Tom wasn't finished making contributions to the world of math research. It was 13 years later that Tom had his greatest success: at age 59 he published a groundbreaking paper in the *Annals of Mathematics*, one of the top math research journals in the world. His paper was about the Twin Prime Conjecture, an extremely important problem in number theory. The Twin Prime Conjecture is almost two centuries old, but there had been very little progress towards cracking it for decades. Tom's paper didn't solve it completely, but it took a huge step forward, and opened new floodgates for researchers who were able to build on Tom's work. His paper has been recognized as a masterpiece and a work of great genius by math scholars everywhere.

After publishing his magnum opus, Tom became a mini-celebrity in the world of math. He got an offer to be a full professor in the University of California system - to be an equal colleague with some of the best mathematicians in the world. Journalists wrote glowing profiles about him in the *New Yorker* and other prestige media outlets. Most importantly from Tom's point of view, his work made a serious contribution to the world of number theory and will forever be recognized as an important contribution to humanity's scientific knowledge.

Tom Zhang's journey is a remarkable one: from humble origins in a poor family, to a decade of forced labor, to a failure to start an academic career, to years in the wilderness working odd jobs for low pay, and finally to recognition as one of the top mathematicians in the world. Though Tom's story is amazing and even seems miraculous, it is not entirely unique. Many of the greatest scientists of all time spent many painful years being dismissed as crackpots by the scientific establishment and even by their friends and

families. Many of the greatest scientists of all time spent years or lifetimes as misunderstood outsiders.

Consider Ignaz Semmelweis. Today, we recognize him as a hero of science for pioneering something that seems painfully obvious: the idea that doctors should thoroughly disinfect their hands and equipment before performing surgery. But Semmelweis's ideas did not always seem obvious. They met broad rejection from the scientific establishment during his lifetime. Semmelweis spent nearly twenty years pleading with hospital administrators all over Europe to implement the sanitation practices that had saved the lives of so many of his patients. Remarkably, they all ignored him, even when he prepared reports of mortality statistics that showed enormous improvements in mortality rates resulting from simple hand washing.

The rejection that Semmelweis faced for decades led him to be depressed and to behave erratically. Even his wife thought that he was insane. Eventually, his colleagues had him committed to an insane asylum, where he died, having spent decades trying and failing to convince the world that a simple wash of a doctor's hands can save many lives. Semmelweis faced a tragic end because his colleagues and even his family thought he was a crackpot and a dangerously deluded man with misguided ideas. But Semmelweis's ideas were not ignored forever. After his death, hospitals around the world slowly started to adopt the practices he had advocated throughout his career, and today we revere him as a great visionary whose scientific ideas have saved countless lives.

Like Tom Zhang, Semmelweis was knowledgeable, talented, industrious, and insightful. But despite his success decreasing hospital mortality rates, he was dismissed as a foolish crackpot for many years: he was fired from his hospital job, mocked, rejected, and ignored. Semmelweis and Tom Zhang live a continent apart and in different centuries. But both of their lives are examples of a powerful story that has repeated throughout history: the story of a misunderstood outsider scientist who was considered a crackpot, but whose ideas were eventually accepted and honored. It's the story of the crackpot who was vindicated. It's a story that has repeated again and again throughout the centuries of human civilization.

Stories like these have the power to make us rethink how we treat outsiders and sandwich shop employees. They can make us reconsider what we think is true, and make us wonder whether there are any ideas now rejected as crackpot notions that we'll all eventually accept. On a human level, when we read stories of crackpots who changed the world, we can accompany them on the journey of their lives. We can empathize with them as we learn about their low points of rejection and failure, and exult with them as we learn about their great triumphs. Learning the history of misunderstood crackpots who changed the world will take us around the globe and millennia into the past, and it will even make us rethink what we expect from the future.

The Worldwide History of Crackpots

When we say someone is a crackpot, we might mean it as a light criticism, like saying that someone is eccentric or impractical. But when we're talking about scientists, or would-be scientists, to say that someone is a crackpot can be a more serious accusation, and often implies that their scientific ideas are wrong, or at least that their ideas fly in the face of accepted conventional wisdom. Crackpots are usually mocked and rejected for their strange ideas. They're always outsiders in one way or another.

But the important thing to remember about being an outsider is that it's entirely a matter of perspective. To be outside the Northern Hemisphere is to be inside the Southern Hemisphere, and vice versa. To be outside the scientific mainstream might be lonely or uncomfortable. But now and then it also means being inside the sanctuary of scientific truth. When Tom Zhang was working at Subway, people may have thought he was a deluded crackpot because he believed he was a great mathematician and none of the other billions of people in the world agreed. But he must have known the truth: that he was the only sane one and all of the billions of people who didn't believe in him were the real deluded crackpots.

Like orchids, there are many varieties of crackpots. Some are scientifically literate but socially inept. Some crackpots hold views that are 99% in line with the conventional scientific wisdom, but still hold on to a few beliefs that seem eccentric, unhinged, or delusional to everyone else. Some have a harmlessly unique personality, and some are criminally insane. All face rejection by their peers. Not all who are regarded as crackpots overcome this rejection. But in this book we will focus on the success stories: those who overcome the rejection of their peers and are eventually hailed as geniuses who made real contributions to the world science.

In the world of science, there has never been a shortage of brilliant eccentrics and crackpots. If you've studied the history of science, you probably know about the ancient Greek astronomer Thales of Miletus. Thales was so interested in stars and planets that were millions of miles away that he tended to ignore some important things that were much closer. According to one story, he was once so enraptured as he looked at the stars that he fell into a well. The story became so famous that it was immortalized in Aesop's Fables, and even Thomas Aquinas wrote about it in one of his Aristotelian commentaries. The foible of Thales is one that we see reflected in the life stories of many other great scientists throughout history: they focus so much on science that they don't have any energy or attention left to spare on the mundane concerns of life. Their lack of attention to more "normal" daily concerns or social conventions often causes them to be seen as strange or eccentric.

Thales wasn't the only scientist who struggled with the conventions of normal life. The struggles that Archimedes faced with social taboos are well-known to students all over the world, who often hear the story of his bathtub epiphany in their grade-school science classes. The beginning of the story, when Archimedes suddenly thought of a way to measure the purity of a crown while he was in the bathtub, is not not so strange on its

own. Scientists have studied creative epiphanies and have even published papers claiming to explain why we can do our best thinking in the bath or the shower. The eccentric part is what Archimedes did next: supposedly, he ran through the streets naked, shouting "Eureka!" in excitement about his idea. (At least he was bathing in the first place. Steve Jobs, another eccentric genius inventor, was known for bathing rarely, to the point that his colleagues hired a new CEO for Apple whose first assignment on the job was to convince Jobs to bathe more.)

It's one thing when a scientist's eccentricity only leads to funny stories or social faux pas. But sometimes, the unusual behavior of scientists leads to great losses of important scientific knowledge. The great Japanese mathematician Kurushima provides an example of this. He filled many manuscripts with calculations and mathematical ideas. But once, when he had to go on a long journey, he used his manuscripts to repair holes in his luggage - maybe to avoid spending too much money on the expensive leather that would be needed to repair the luggage properly. To this day we don't know what was written on the manuscripts he used to accomplish the repairs - maybe he had jotted down some breakthrough theorems that would have changed all of mathematical history forever. But because of his eccentric idea about how his luggage should be repaired, today we have only the story.

Sometimes, eccentricity goes beyond behavior that's merely quirky or funny. Pythagoras, revered as he is today for his immortal mathematical teachings, also held many beliefs that we regard as crackpot notions today. He taught numerous dietary restrictions, like a prohibition on fava beans, to his followers. At one point, his school was attacked by an angry mob that killed many of his disciples. A few sources claimed that as he was running away from the mob, he encountered a fava bean field and was forced to stop because of his beliefs that fava beans should always be avoided. While he was pausing at the edge of the fava bean field to consider how to get around it, the mob caught up to him and killed him. In Pythagoras's case, crackpot beliefs caused not only a fall or an embarrassing streaking episode, but a tragic death.

Empedocles was yet another ancient Greek scientist who died because of his crackpot beliefs. When thinking about nature or science, Empedocles was widely respected and even revered as a great genius. But his beliefs about himself were less well-founded. One of his biographers said that he bragged to his followers that he was immortal, or even a god. To prove that he was a god, he jumped into a volcano, promising that the heat wouldn't harm him and he would jump right back out, unscathed. On this rare occasion, he was wrong: another awful consequence of holding just one incorrect crackpot belief.

The list of scientists and scholars who were genuinely mentally disturbed is remarkably long. One of the leading etymologists who contributed to the original *Oxford English Dictionary* (OED) was William Chester Minor, a brilliant man who had been a successful physician before learning linguistic history and dedicating himself to help write the OED. James Murray, the primary editor of the dictionary, was extremely thankful for the numerous valuable contributions that Minor made to his work over the course of many years. It was only after Murray wrote a letter to Minor to ask to meet him in person that

he found out where Minor had been mailing his contributions from: an insane asylum where Minor was a prisoner! Minor had been incarcerated in an institution for the criminally insane ever since he had shot a man in the streets of London years before. Some psychiatrists today believe that Minor suffered from schizophrenia - a disease that caused him to behave eccentrically and even criminally, but didn't slow down his prolific linguistics research.

A more recent and even more tragic example of a mentally disturbed but brilliant scientist is Ted Kaczynski. Throughout his young life, everyone who knew Kaczynski recognized him as a math genius. His career as a mathematician reached its pinnacle in 1968, when he was appointed an assistant professor at Berkeley at only 26 years old. You probably know the unfortunate remainder of the story: he quit his job suddenly and moved to a remote cabin in the woods. There, he made bombs, sent them to his enemies, and ended up killing or injuring dozens of people. Kaczynski was not only brilliant and eccentric, but also criminally deranged, and his story shows the danger of the temptation that brilliant people often face to withdraw from the healthy social life of society.

Sometimes, behavior that seems eccentric or strange is merely ahead of its time. The great inventor Heron of Alexandria was the first inventor of a vending machine: his device dispensed holy water every time a coin was inserted. But his vending machine never caught on in his Roman society, and vending machines didn't catch on commercially for many more centuries. Heron's contemporaries must have thought he was strange or a crackpot for inventing something like that, and they may have even thought him a failure since his invention never earned him any money. But now, we can look back and see that though eccentric, he was a visionary.

On the other side of the world, Zhang Heng was one of the greatest minds of ancient China. He spent years designing and building a seismoscope, a device that could measure the strength of earthquakes and even determine the direction from which they originated. But his ingenious invention was before its time: no one in the world understood plate tectonics, or the layers of the earth, or the best ways to prepare for or predict earthquakes, so knowing the general direction of an earthquake's origin didn't have any practical use for many centuries. Like Heron of Alexandria's contemporaries, maybe Zhang Heng's contemporaries thought was strange, eccentric, or a failure for creating something so practically useless. But now, we know that he was ingenious, and merely ahead of his time.

Sometimes, a great scientist gains a reputation for being a crackpot not because of his eccentricity or strange behavior, but instead because of the slander of his enemies. John Gorrie was a victim of such slander. He started his career in 1833 as a successful physician in a coastal town in Florida, and he was even elected mayor of his town. As a doctor, he was constantly appalled to see his patients suffer when their fevers were aggravated by the high heat and humidity of the local climate.

At age 42, Gorrie stopped working as a doctor, and became a full-time inventor, working tirelessly to invent a form of air conditioning based on an idea he had for artificially

producing ice even in a hot climate. Gorrie knew that air conditioning had the potential to improve the lives of his patients as well as all the ordinary people who lived near him. But a powerful businessman named Tudor wanted him to fail. Tudor made his money by shipping ice from frozen lakes near Canada to wealthy people in Florida and the Caribbean, so of course any inventor who could make ice in Florida would threaten his livelihood. Tudor launched a concerted campaign to slander Gorrie as a deluded crackpot whose invention would never work.

Between Tudor's campaign, and the bad luck of a financial backer suddenly dying, Gorrie was never able to earn any money from his invention, and died alone and in poverty soon afterwards. But since his death, Gorrie has been recognized as a visionary and a great inventor, and his town has even erected a monument to his memory.

Outside of the world of science, there's also no shortage of eccentrics, outsiders, and crackpots. We now recognize Socrates as one of the great thinkers of all time, but in his own time he was ostracized and sentenced to death for his unique beliefs and practices. Joan of Arc believed that she had been chosen by God to lead her people in battle. Many people, then and now, have regarded her claims about visions to be eccentric or even crazy, but no one fails to admire her audacity and leadership. In later centuries, the Age of Exploration was full of eccentrics like Christopher Columbus who held crackpot beliefs like the notion that entire continents lay beyond a frightening, distant horizon. Without such outsider eccentrics willing to risk everything for controversial beliefs, new parts of the world would never have been explored and connections between distant peoples never forged. We can thank eccentric outsiders and crackpots all over the world for scientific discoveries and brave leadership throughout all the centuries of humanity's existence.

Crackpots Today

From Archimedes to Semmelweis to Tom Zhang and beyond, crackpots often have painful experiences or hard lives. To be brilliant often means to think differently than others do, to understand the world in a different way, and to have different goals and ideals than your peers. But the more differently you think, the more likely you are to be mocked or misunderstood or rejected. Every crackpot faces painful rejection or mockery at some point in their lives.

But the difficulty of crackpots' lives can be part of what makes their stories so compelling. After being derided and disdained by their peers, many crackpots are vindicated: their ideas are finally accepted, their inventions are finally used, and they finally receive the respect and accolades they deserve. The brilliant crackpots of history provide some of the most inspiring stories of all time, taking us on a roller coaster from discovery through failure and rejection and finally to sweet triumph.

What could be more inspiring than an underdog ending up on top? G.K. Chesterton described the glory of the lives of crackpots, writing that "the one perfectly divine thing, the one glimpse of God's paradise given on earth, is to fight a losing battle - and not lose

it." Through the lives of Tom Zhang and Semmelweis and many others, we can get the glimpse of paradise that Chesterton described.

When we reflect on Tom Zhang, a great mathematical genius working part-time at Subway to make ends meet, it can make us see the whole world differently. Every time you meet a minimum-wage worker at a sandwich shop, you should remember that they might someday be recognized as a great math genius or a world-renowned artist or a fabulously wealthy CEO. At the very least, they're certain to be a worthwhile person. Dale Carnegie said that as we go through the world or walk down the street, every day we're "rubbing shoulders with millionaires." By learning about Tom Zhang, we can realize that we're also rubbing shoulders with math geniuses, even at sandwich shops. Knowing about Tom's story can change the way you look at the world and your fellow man.

The other thing we can learn from Tom Zhang's story is the value of persistence. Today, you may feel as lonely as Tom Zhang did in 1997. You may feel like your job is as dead-end and unrewarding as he felt his was. You may even feel as lonely and marginalized as Semmelweis in 1865, who was committed to an asylum and beaten to death! But remember that there's great value in long persistence, even when everything seems hopeless. Tom Zhang could have given up at age 42, resigning himself to a life of low-wage jobs without any mathematical success. Semmelweis could have given up after nearly 20 years of attempts to get his ideas accepted. Neither gave up, and both are recognized today as great geniuses and heroes of the world of science. Both have given great gifts to humanity.

Another lesson we can learn from crackpots is that dreams really do come true. No matter your background, no matter your education, no matter your situation, you can make it to the top, and change the world. Even if all the people around you consider you a crackpot, it doesn't mean you have to give up. Even if you feel like you're at the lowest point of your life, if you keep going, you can make a great contribution to the world just like Tom Zhang and Semmelweis and countless other crackpots have done through all the centuries of human civilization.

In this book, we'll focus on crackpots who were mocked and rejected because their scientific ideas were believed to be wrong, but who were eventually vindicated. We'll travel around the world and through time to learn about these scientists. We'll feel their pain and exult in their triumphs together. We'll examine the individual strengths of each of them, and consider how we can become more like them. We'll see the place that crackpots have had in scientific history, and how their contributions are often ignored and mocked by their peers. We'll see in vivid detail how misunderstood outsiders can change the world.

Ignaz Semmelweis: the Power and Peril of Obsession

If you've read Victor Hugo's grand novel *Les Misérables*, or if you've seen any of the musical or film adaptations, you probably love the story's hero, Jean Valjean. After serving a nineteen-year prison sentence for stealing bread to feed his starving relatives, Valjean is set free, turns his life around, and in turn saves others' lives. It's much harder to love Valjean's nemesis, the fanatical policeman Inspector Javert. Javert spends years obsessively hunting Valjean and refuses to forgive him for even his smallest infractions. Since he thwarts so many of Valjean's plans and desires, it's tempting to think of him as the story's villain.

But there's another way to see Javert. Remember that Valjean was a parole-breaker several times over, and a recidivist: he committed theft more than once even after being set free. Catching serial thieves is a socially important job that keeps us all safe, and Javert was doing it with great dedication, despite Valjean's talent for hiding and escaping. Javert faced a catch-22: if he were in any way lax in his job performance, countless thieves and criminals would go free and cause untold suffering to their victims. But since he was unfailingly industrious at his job, readers see him as a deranged fanatic who couldn't let things go.

Javert faced an impossible situation and made a heroic choice: to work tirelessly at establishing justice. He was rewarded by generations of novel readers considering him a detestable extremist. Maybe Javert is really the hero of the novel. At the very least, we should reconsider our opinion of him, and try to love him after all. If we hate Javert, then we are hating him for the dedication that made him good at his important job. His obsessiveness was both his power and his peril.

This is not only a problem for fictional French detectives. The prominent statistician Andrew Gelman has written about what he calls the *Javert Paradox* in the world of science. He described this paradox as follows:

"Suppose you find a problem with published work. If you just point it out once or twice, the authors of the work are likely to do nothing. But if you really pursue the problem, then you look like a Javert."

One striking example of the Javert paradox in science occurred in 2016, in the world of academic psychology. For a few years leading up to that time, some established, senior scientists had published research purporting to prove some psychological theories. Some of these theories were related to the psychology of eating, and some supposed psychological tactics for "tricking" oneself into eating the right amount of healthy food. These theories were broadly accepted both inside and outside of academia, and they got fawning coverage in the press.

Before long, other researchers began to criticize these theories and the methods that were used to supposedly prove them. These critics found that meekly pointing out errors in

private emails led them to be ignored by the scientific establishment. So, some of them "went full Javert," spending months or years conducting extended letter-writing campaigns and repeatedly publishing refutations online and on social media. Criticizing and refuting incorrect theories like this is the scientific equivalent of police work: it keeps wrong ideas "off the streets" so they don't damage our understanding of the truth.

But the established researchers and journal editors whose work was being criticized felt personally attacked when these critics worked so hard to tear down their achievements. They probably felt like Valjean: as if fanatical scientific Javerts were unforgivingly trying to punish them despite their good intentions. Eventually, a former president of the Association for Psychological Science wrote an editorial in the *APS Observer* (a scientific journal) about the critics of the accepted theories of the field. She called the critics "self-appointed data police," whose "unmoderated attacks" cause damage to scientists' careers, "with no accountability for the bullies." She escalated her language later to describe the "sheer adversarial viciousness" of these attacks on accepted theories, which she referred to as "methodological terrorism." The author of this editorial was not alone in her negative reaction to scientific criticism: an article in the *Chronicle of Higher Education* later called these same researchers "data thugs." This reaction, from the top of the scientific establishment, shows the reception that a tireless, unflinching pursuit of scientific truth too often gets, even today: a cold one.

Eventually, the incorrect theories were overturned, and empirical psychological science today is still marching (or at least limping) forwards. But while the author of the name-calling editorial still has tenure at a top university, one of the leaders of the "data thug" critics was forced to leave his graduate school program without a degree because of the backlash. Pursuing a worthy cause, whether it's thief-taking or scientific rigor, can be a thankless job. If you're lax in your pursuit, things slip through the cracks, thieves go free to victimize others, and bad scientific ideas creep out into the world. If you're industrious in your efforts, you get maligned and detested like Javert. We should all be grateful for obsessive people who have both the fortitude to work hard for many years on important goals, and the thick skin to tolerate the excessive criticisms and reprisals they're likely to face.

Ignaz Semmelweis was the scientific Javert of his generation. He found a major problem with the scientific theory and practice of his day. He felt that fate had chosen him to correct this error and thereby save countless lives and improve the world. He didn't merely state his opinions and retire - he spent decades obsessively studying and then writing papers, books, lecture notes, and letters to push his discoveries all over the world. Many of those who he strongly criticized felt offended and attacked by his efforts and became his implacable enemies. Semmelweis didn't let this opposition stop him - he had chosen a worthy cause and he pursued it energetically until the very end of his life. But the obsessive dedication with which he pursued his cause - the very obsessiveness that enabled him to be so effective - also led eventually to his own miserable ruin.

Fate's Choice

Semmelweis was born in 1818, in modest, middle class circumstances. His father was a successful grocer in what is now Budapest, Hungary. His childhood was happy, and he was described as a bright and friendly young boy. He attended a local Catholic school and was liked by his teachers and classmates.

But even from the earliest parts of his life, Semmelweis's circumstances marked him as an outsider. He lived in Hungary, but his family didn't speak Hungarian at home, instead speaking the nonstandard Swabian dialect of German. Speaking Swabian German meant that he would be considered an outsider not only in Hungarian-speaking Budapest, where he was born, but also in German-speaking Vienna, where he would establish his career. In Vienna, most of his colleagues and bosses would be Standard High German speakers who thought his accent was provincial and unsophisticated.

Nevertheless, Semmelweis was happy as a child, and excelled at school. When he started his university studies, he began as a law student, since his father had encouraged him to become a military judge. But before the end of his first semester, he witnessed something that made him completely change his focus: a human dissection.

Most of us feel nothing but disgust when we think of viewing a human dissection. Semmelweis himself was initially repulsed by the smell from the body, even at a distance. But he had a naturally scientific mind: highly observant, methodical, and deeply curious about the inner workings of complex systems like the human body. Medical dissection is more than just cutting flesh. The great pathologists of history have used dissection to learn the deep secrets of human anatomy. The anatomical discoveries of pathologists, like William Harvey's description of the circulatory system, have led to great advances in medical theory, practice and technology.

Nineteenth-century Vienna was an especially auspicious place to study dissection and pathology, since a few great doctors there were pioneers of a brand new field of medicine called forensic pathology. Forensic pathologists in Vienna performed many thousands of meticulous autopsies of deceased patients over their long careers. By analyzing the diagnosed disease of the patients, and finding which features of the corpses correlated to the diagnosed cause of death, pathologists were able to better understand the nature of disease and the effects of disease on the body. This work eventually led to better diagnoses and treatments for the living. Looking at clues, finding the cause of an unexpected death - it's much like detective work, not unlike Javert's vocation.

Compared to studying the abstruse laws of the Austrian Empire, the experience of seeing one of the world's top forensic pathologists at work was thrilling for Semmelweis. It motivated him to immediately drop out of his law school and enroll as a medical student. Within a few years, he had graduated and needed to get his first job. Just like medical students today, Semmelweis had to choose a specialty - a type of medicine that would be the focus of his career.

Since dissection was what inspired his interest in medicine, it was natural that Semmelweis applied to work as a pathologist's assistant as his first choice. But he didn't get the job. Next, he applied to work as an assistant to a diagnostic specialist, but that position had already been filled. As a fallback, a friend convinced him to try a short stint working in obstetrics, which he had never considered.

Today, we know that Semmelweis was one of the great medical geniuses of all time. This is why it's so surprising to learn that he got neither of the first two jobs he applied for after graduation. Like all of the heroes of this book, his great talents took much too long to be appreciated. Nevertheless, we'll see that even in the moments of his first failures, the seeds of his later success were already being planted. Even though obstetrics was a more-or-less random fallback position for Semmelweis, it was in that field that he was able to make one of the greatest breakthroughs in all of medical history.

Semmelweis found that he enjoyed obstetrics, and was excited to have the chance to make a difference in patients' lives. He later noted why he extended his obstetrics stint and continued with the field for the rest of his life:

"Medicine's highest duty is saving threatened human life, and obstetrics is the branch of medicine in which this duty is most obviously fulfilled. Frequently it is necessary to deliver a child in transverse lie. Mother and child will probably die if the birth is left to nature, while the obstetrician's timely helping hand, almost painlessly and taking only a few minutes, can save both."

But it wasn't only the saved lives that motivated him - he was also deeply affected by the deaths. He wondered what caused them and whether they could have been prevented. At the time, the causes of most diseases were unknown, and treatments for most diseases were primitive. All too often, doctors could do nothing more than sit by and watch a disease slowly drain the life from a patient. For Semmelweis, this ignorance and inaction was unacceptable - he had to know what was causing seemingly unnecessary deaths, and he fervently wished to do whatever he could to prevent them if he could. In order to gain better understanding of the causes of terminal diseases, he would have witness and study the circumstances of many deaths.

There was no shortage of deaths for Semmelweis to witness and study in the maternity clinic where he worked. Besides all of the complications that can make pregnancy dangerous even today, Semmelweis's clinic was constantly ravaged by an awful disease called childbed fever. Countless healthy women would enter the maternity clinic, deliver a baby with no complications, and very shortly afterwards, the telltale symptoms would set in. Those symptoms included violent shivering fits, "acute pain," dry tongue, shortness of breath, anxiety, bloodshot eyes, extremely high temperatures, and delirium. Childbed fever could cause a young woman to go from perfect health to death in only a few days. After symptoms were observed, the death rate was about half.

A 50% death rate, and not a death in pleasant, comfortable circumstances. No one likes to be in a hospital, but descriptions of European hospitals of Semmelweis's time are extremely dire. Even in great centers of learning and wealth like Paris, many patients would be crammed together in a single, small bed. Surgery was often performed in the same room or even the same bed where other patients were resting or waiting for their own turn under the knife, and always without anesthetic. This meant that nothing would separate bystanders from the screams, stench, and blood of surgery, or the frequent sight of life giving way to painful death.

It would be heartbreaking to witness a sudden, painful death in such dreadful surroundings even once. But as an obstetric physician in an urban charity hospital in the mid-nineteenth century, Semmelweis would have seen women die of childbed fever nearly every day. Each of these individual deaths affected Semmelweis. He expressed a great desire to "preserve the wife for her husband, and the mother for her child" in his work. Tragically, at the time, neither the causes nor any effective treatments for childbed fever were known, so a physician who observed it would be doomed to merely sit and watch it unfold, hoping for the best while all too often helplessly witnessing the worst.

Semmelweis's switch from pathology to obstetrics was necessary because of his failure to get the job he wanted. But this switch, though motivated by failure, was a large part of what led him to become the great man we know he became. He was able to directly help the poor and most unfortunate of his time, most of them outsiders just like he was. It was through his obstetrics work that Semmelweis accomplished the most important work of his life: the identification of the cause of childbed fever, together with an understanding of how to prevent it.

For those who believe in Fate or Providence, it is easy to see in Semmelweis's career trajectory a perfect confluence of events - one that appears almost divinely ordered. His interest in forensic pathology gave him an understanding of the latest methods for discovering the causes of diseases, and an enthusiasm for making these discoveries. But if he had studied forensic pathology alone, he may have spent his whole career locked in an ivory tower, studying theories and never directly helping patients. Instead, he was rejected from the job he wanted in forensic pathology, and had to work in obstetrics. His obstetrics specialty gave him hands-on experience with patients, as well as chances to repeatedly observe the situations that correlated with the onset of childbed fever. The combination of theoretical enthusiasm with practical experience is what led to his breakthrough. It enabled him to have the great ability of the best scientists: an ability to think deeply about theory, but also apply detailed, meticulous observations gained during practice.

With hindsight, we can see all of this, and even judge that his career path may have been ordered by Fate or Providence. But at the time, Semmelweis was just another young man like most of the rest of us: eager to make his mark but rejected from his dream jobs, trying his best to make a living and do right and make good while feeling insecure about his outsider status and failure to be respected in the way he wished for. Even if he had been chosen by Fate, his path to greatness was never a straight one. It required great

sacrifice, and included many formidable obstacles and heart-wrenching failures along the way.

The Data Scientist

Semmelweis was a doctor, and he is remembered today as a hero of the world of medicine. But his real breakthrough was actually a triumph of data analysis. Later in life, when he wrote a book about childbed fever, he started by describing the complete insufficiency of contemporary medical science to understand the cause of the disease. Then he turned directly to data, including statistics about mortality after only three paragraphs. He solved the puzzle of childbed fever less through advanced medical theories, and more through thorough analyses of data and a generous helping of logic.

Since Semmelweis turned so directly to data, we should too. The following table shows counts of births and deaths in the maternity clinic where Semmelweis worked at the beginning of his career:

Table 1. Mortality rates in Semmelweis's maternity clinic

	First Clinic			Second Clinic		
	Births	Deaths	Death Rate	Births	Deaths	Death Rate
1841	3,036	237	7.81%	2,442	86	3.52%
1842	3,287	518	15.76%	2,659	202	7.60%
1843	3,060	274	8.95%	2,739	164	5.99%
1844	3,157	260	8.24%	2,956	68	2.30%
1845	3,492	241	6.90%	3,241	66	2.04%
1846	4,010	459	11.45%	3,754	105	2.80%
Total	20,042	1,989		17,791	691	
Avg.			9.92%			3.88%

These numbers are shocking, even if you don't have a background in statistics or medicine. The "Second Clinic," staffed by midwives (all women), had a high mortality rate - over three percent across six years. The "First Clinic," staffed by doctors (all men), had a mortality rate that was truly appalling - nearly 10 percent over the same six years.

For Semmelweis, these were more than only numbers. He spent countless hours in the First Clinic, where he saw these women and their babies die in front of his eyes. By tradition, each dying woman had last rites administered to her before passing away. When administering last rites, the clinic's priest would walk from the chapel to the bed of the dying woman, with an assistant walking in front of him, ringing a bell loudly to announce the priest's arrival for the ritual. Semmelweis, either working with patients, or in his office, could hear the bell all too often, sometimes many times in a day. At one

point, he described the sinking feeling he got every time he heard the priest go past his door to administer last rites for a victim of childbed fever:

"...to me it was very demoralizing to hear the bell hurry past my door. I groaned within for a victim who had fallen to an unknown cause. The bell was a painful admonition to seek this unknown cause with all my powers."

Stalin famously wrote that while one death is a tragedy, a million deaths is a statistic. Hospital administrators, including Semmelweis's bosses, must have had something like this feeling. Thousands of people died in Semmelweis's hospital - reportedly over 200 thousand in its first 88 years of operation. Maybe it was easy for head administrators of the hospital to look at high mortality numbers and shrug, hoping for improvement but not terribly affected by numbers on a page about strangers. For Semmelweis, the deaths were not only statistics - they were last rites bells going past his door, and suffering, impoverished mothers crying out desperately for help in front of his eyes. He had that rare combination that the best medical scientists share: a strong heartfelt feeling for each individual, plus a grounded, clear-eyed analytical understanding of the statistics.

If we can get past the initial shock and horror of seeing the numbers in Table 1, we can start to think about what they mean. This is precisely what Semmelweis did. He lived before many of today's modern methods of statistics and econometrics, but he followed rigorous methods of reasoning and deduction that anticipated the most advanced statistical analyses of today.

Try to look at Figure 1 as if you were an honest, well-intentioned Austro-Hungarian doctor in the middle of the nineteenth century. You can see that there are different mortality rates in the two clinics. How could these differences be explained, and what did they mean?

The first thing a statistician might do after seeing the numbers presented in Table 1 would be to check whether the different mortality rates in the two clinics could be explained away as a coincidence. Sometimes, a clinic might have some bad luck, or one or two random deaths that could skew the death rates one way or the other. Statisticians are interested not only in differences between numbers, but in *statistically significant* differences - that is, differences that are not consistent with random variation and coincidences.

Today, we would do something called a two-sample proportion test (a version of Student's t-test) to determine whether the differences between clinics could plausibly be due to coincidences. If you performed this test with the data in Table 1, you'll find that the probability of observing mortality rate differences this large by coincidence is much less than one in a hundred million. But the t-test would not be invented until eleven years after Semmelweis's death. Throughout his career, Semmelweis would have to repeatedly argue that the differences he observed in this table were not due to coincidence, but

instead represented one of the keys to understanding the cause and prevention of childbed fever.

In hindsight, many of the scientific breakthroughs of the past seem obvious. But we have to remember that the scientists of the past were working with imperfect tools. Semmelweis wanted to do statistical analysis, but not even the t-test, the most basic of today's common statistical tests, had been invented. He wanted to understand disease, but microscopes were not very advanced, the inherited medical theories were usually wrong, funding was never enough, record keeping was not always rigorous or honest. We should grade the scientific past on a steep curve - scientists in all times are usually doing their best with extremely limited tools.

After being certain that the two clinics had death rates that did indeed differ more than would be expected by coincidence, the next question we might ask is one of causality: what is it that caused the death rate in one clinic to differ from the death rate in the other? This is a much harder question to answer. We might consider three options:

1. There's something unique about the First Clinic that causes people to die there, while Clinic 2 doesn't have that death-causing attribute. For example, something about the way deliveries are performed in Clinic 1 or the standards of hygiene there could cause much higher mortality rates.
2. The First Clinic is identical to the Second Clinic, but dying itself might cause people to go to the First Clinic. For example, suppose that the nurse who admits patients to the clinics assigns the special or complicated cases to the First Clinic, and the straightforward, safe cases, to the Second Clinic. This is called reverse causality - it's not that the First Clinic causes death, it's the reverse, that being near death leads to admission to the First Clinic. This reverse causality leads to what's called a selection bias, meaning that the groups going to one clinic or the other have systematic, important differences from each other because of the way they've been selected.
3. Something else, like some external element, causes death and also causes people to go to the First Clinic. For example, extreme poverty leads people to be unhealthy and to die at higher rates. If the First Clinic had a lower entrance fee than the Second Clinic, then it could be that poverty itself caused both death and an economic preference for the First Clinic. If we don't know or can't measure the external cause of both death and admission to the First Clinic, we call it an "omitted variable." When there's an omitted variable that influences an analysis, it could lead to an "omitted variable bias."

In some cases, we see medical data, and assume we're solving a medical problem, but we're really solving an entrance fee problem (like the omitted variable example in #3) or a triage nurse problem (like the selection bias described in #2). The most effective tools we have today to answer these kinds of questions come from econometrics, which has developed ingenious methods for determining causality. Econometrics experts spend entire careers worried about reverse causality, selection biases, omitted variables, and other challenges that come in the way of connecting causes to effects.

The best solution to most of these problems in econometrics is to find a "quasi-experiment," that is, a feature of the world that makes assignment to clinics essentially random, like an experiment. Luckily, that is exactly what Semmelweis found. It turned out that patients arriving at Semmelweis's hospital were assigned to one of the two clinics based on the time of their arrival, with Monday arrivals being assigned to the First Clinic, Tuesday arrivals being assigned to the Second Clinic, and so on alternating throughout the week. Since assignment to clinics isn't based on the severity of diagnoses, we can dispense with explanation #2. Since it isn't based on fees or individual choice, we can dispense with explanation #3. Since the assignment of patients to clinics is more or less random, the only explanation left is #1, that there is some attribute of Clinic 1 that is causing the much higher death rate. But what attribute could it be?

One of the most obvious hypotheses for the different mortality rates in the First and Second Clinics is that the difference is due to the gender of the staff members. In Semmelweis's day, some suggested that the male doctors in Clinic 1 were guilty of "examining the patients in a rougher manner" than the female midwives in Clinic 2, for example. Others suggested that the presence of males at delivery caused an "offense to modesty" that, through psychological means, led to illness and death. In principle, it could even be that the midwives were simply more talented than the doctors in the art of delivering babies, or that they had tacit knowledge or deep childbearing lore that they passed on that the doctors didn't possess.

Semmelweis considered these gender-difference hypotheses, but refuted them with several different arguments. As for the greater roughness of male vs. female attendants, he noted that no amount of roughness in a normal person's medical examination could possibly come close to the roughness of a baby going through a birth canal, so slightly rough examinations wouldn't be sufficient as an explanation of the cause of childbed fever. He also noted that any observer of the clinic would know that its patients were troubled by fear, but not by modesty. As for differences in skills, he noted that the same practices were followed in both clinics to deliver babies. The different death rates didn't seem to be a matter of attributes directly related to gender.

Besides "offended modesty," there were other theories that relied on supposed psychological causes of childbed fever. Some suggested that the greater death rate in the First Clinic was the result of a self-fulfilling prophecy: women heard that the death rate there was higher, so after they were admitted, they felt greater fear. Others suggested that the bell that rang out to announce the arrival of a priest to give last rites, sometimes several times a day, was frightening to the women. According to these theories, fear itself caused women to contract childbed fever.

Regarding explanations based on fear, Semmelweis pointed out that soldiers in battle must feel a comparable fear of death, but they were not known to frequently contract childbed fever. Here again Semmelweis was ahead of his time: he was using exactly the logic that the philosopher Karl Popper later said was the basis of the scientific method. Popper described science as follows: first, a hypothesis is described. Then, the

implications of that hypothesis are explored. If the implications of the hypothesis are not true, then the hypothesis itself must be untrue. Popper described this logic many decades after Semmelweis's death, but Semmelweis was already using it to do science, well in advance of its full explication.

Even though he didn't believe that fear was causing childbed fever, Semmelweis made arrangements for the priest to take a different route through the clinic that wouldn't require him to toll a bell so conspicuously in front of so many anxious, living patients. He reported that this change also made no difference to death rates. (It seems clear that he never thought it would affect death rates - he pleaded with the priest to change his route strictly out of compassion for his patients' feelings.)

There were many other explanations that had been suggested for the higher mortality in the First Clinic, and Semmelweis considered each of them in turn. Some had suggested that overcrowding was the key factor that caused a difference, or even the floor plans that led to different exposure to cold, or the way the laundry was done, or the manner of ventilation, or the changing of the seasons.

Semmelweis refuted each of these hypotheses in their turn. Some were based on incorrect data, some were contradicted by experiments and careful studies. For each of the standard theories of the cause of childbed fever, there was no evidence. Refuting each theory was progress because it took him closer to the truth. But he still hadn't found a correct explanation. Semmelweis still had no clear idea of what caused this awful disease.

One thing that Semmelweis was always certain of was that the outbreaks of childbed fever were not due to epidemics. At the time, epidemics of diseases were regarded as being caused by a combination of weather and influences from the atmosphere. Since weather and atmospheric conditions are not localized to individual clinics, but instead prevail over large areas the size of a city, it wouldn't be possible for an epidemic to affect the First Clinic without also affecting the Second Clinic. But Table 1 showed that the clinics had strikingly different mortality rates, indicating that a large-scale city-wide epidemic wasn't the cause.

So far, Semmelweis's data analysis had mostly led him to negative conclusions: childbed fever wasn't an epidemic, it wasn't caused by fear or roughness or ventilation or overcrowding or any of the other common explanations of the time. But he still didn't have a positive explanation of what caused childbed fever, and the scientific tools he could use to find the explanation were extremely scant. He didn't know the way forward, but he was gradually committing himself to the mission that would define the rest of his life: to find out the cause of childbed fever, and stop the unnecessary suffering and death that it was causing every day in clinics all over the world.

The Low Point and the Breakthrough

In the years after graduating from medical school, Semmelweis was doing a remarkable and historic work, by gradually coming to an understanding of the extremely difficult

medical mystery of the cause of childbed fever. But professionally, he was struggling even to hold down a job. After deciding to pursue obstetrics as a career, he applied to a job as the First Assistant in the Vienna Maternity Clinic - the same clinic whose mortality rates are shown in Table 1. He was turned down for the assistantship position, and he had to languish for two years as an unpaid "Assistant in Waiting" during this time.

Again, Semmelweis's failure to get the job he wanted must have felt unfortunate, but it led to progress towards his breakthrough. Semmelweis used his years of waiting to study logic and statistics from some of the top physicians of the day. He also used his extra time to pore over the old records of mortality in the clinic, compiling Table 1 and many other tables besides. He wasn't earning money or glory, but he was laying the intellectual foundation of his later breakthroughs. His lack of paid work meant that he didn't have to deal with bureaucracy or get distracted by busywork and committees.

As Semmelweis dug more deeply through hospital statistics and case studies, he discovered an alarming fact. Women who gave birth on the street while traveling to the clinic were much less likely to die of childbed fever than women who gave birth in a comfortable bed attended by a doctor in his clinic. It must have felt awful for Semmelweis to realize that for these patients, his clinic was actually making them worse off than just staying at home or giving birth on the sidewalk.

One extremely important piece of evidence came from the reactions of the patients themselves. Semmelweis noticed that the women in the hospital, though nearly all of them were uneducated and impoverished, had caught on that something was not right about the doctors:

"One sees maternity patients with abnormally high pulse rates, bloated stomachs, and dry tongues (in other words, very ill with [childbed] fever), still insisting only hours before death that they are perfectly healthy, because they know that treatment by the physicians is the forerunner of death."

While the theoreticians and professors of the day were sure that childbed fever came from some combination of atmospheric conditions and psychology and other vague influences, the patients somehow understood that the disease came from what might seem like the most unlikely of sources: the doctors themselves. Semmelweis would later realize that these women were exactly right, and they knew it before Semmelweis or any of the learned professors of the day. Even though none of these women had medical training or advanced knowledge, they had some tacit understanding of the breakthrough that Semmelweis would later make.

After waiting for two years for the position to open up, Semmelweis was finally appointed to be the First Assistant in the maternity clinic. But after only 4 months of what was supposed to be a two-year tenure as assistant, he was dismissed because a previous assistant had asked for his job back. This was probably the worst period of Semmelweis's life so far, because he still hadn't been able to understand why hundreds of women were

dying of childbed fever in front of his eyes every year, and on top of that his father died around the same time that he was fired. He took the sudden opportunity for time off to travel to Venice to calm his nerves.

Codell Carter, a great Semmelweis scholar, wrote that all medical advances are purchased with great sacrifices. In Semmelweis's difficult years of getting rejected and fired and disrespected as he tried to understand the cause of the childbed fever, we can see the sacrifices that he made. The childbed fever patients' suffering is also obvious, and their deaths also contributed to the medical advance. But one more sacrifice was required before the discovery of the cause of childbed fever would become clear.

The final sacrifice that would be the key to finding the cause of childbed fever was the death of Jacob Kolletschka, a friend and mentor of Semmelweis. Kolletschka was a pathologist, and regularly performed autopsies as demonstrations for students. During a routine demonstration while Semmelweis was on vacation in Venice, he pricked his finger with one of his instruments. Within a few days, he was dead.

Semmelweis returned from his Venice trip to learn with great surprise that Kolletschka had died. Upon losing a friend, most of us would react with only depression and grief. But Semmelweis was a true scientist. Instead of only grieving for his deceased friend, he pored over the autopsy notes to try to discover what had caused yet another of his hospital's inexplicable sudden deaths.

Pasteur, a scientist who would later continue Semmelweis's work, once wrote that "fortune favors the prepared mind." Semmelweis had in his hands an autopsy report that would lead to the discovery of the cause of childbed fever. He and all of us were lucky that his mind was prepared - he knew how to read an autopsy, knew the meanings of the obscure notes, and would be able to understand what it all meant for the mystery of childbed fever.

This was the watershed moment of Semmelweis's life. His theoretical understanding of forensic pathology, his numerous experiences with patients and their symptoms, his long hours of reflection; his painful experiences not getting his dream job, then being let go, losing his father, seeing great suffering of patients; his desire to change things, his desire to make a mark, his yearning to make the world better; his early experiences seeing death firsthand among childbed fever victims: all of these things came together in his mind and gave him both the motivation and insight he needed to solve the mystery of the cause of childbed fever.

What Semmelweis noticed in that autopsy report was that Kolletschka's symptoms and post-mortem conditions were nearly identical to the symptoms and conditions associated with childbed fever. But this was hard to explain, since Kolletschka was not a pregnant woman, so childbed fever wouldn't be a natural or even believable diagnosis for him. If we imagine a Venn diagram showing the commonalities and differences between Kolletschka and the typical victims of childbed fever, we can imagine that there is almost nothing in common between them: clinic patients were usually extremely poor young

women, while Kolletschka would have been a middle-aged man in the prosperous upper middle class. Clinic patients were in advanced stages of pregnancy while while Kolletschka was certainly not. What could it be that Kolletschka would share in common with a pregnant working-class girl in the clinic? If Semmelweis could discover what they had in common, he might be able to understand the cause of childbed fever.

Semmelweis could only imagine one thing that Kolletschka and the working-class girls of his clinic had in common: exposure to rotting flesh. Kolletchka was exposed to rotting flesh because he had pricked his finger with a knife that had been recently used on a cadaver. The women of the maternity clinic were exposed to rotting flesh because they were regularly examined by doctors who had just returned from performing autopsies. The answer became clear: it was rotting tissue that caused the disease, when absorbed into the bloodstream through a wound.

This breakthrough was the beginning of a series of several professional successes for Semmelweis. He became the First Assistant in the maternity clinic again after 5 unemployed months. As First Assistant, he was able to implement a policy that hospital staff had to wash their hands and equipment with chlorine before performing examinations. This policy ensured that any particles of rotting flesh that weren't washed off by soap and water would be thoroughly removed from the hands of doctors performing examinations. Mortality rates in the First Clinic immediately plummeted, and hundreds of lives must have been saved within months by this single policy change.

Semmelweis had made the greatest breakthrough of his life. But his work wasn't over. Now that he had come to understand the cause of childbed fever for himself, he needed to make sure that every other doctor in the world believed him and followed his lead in preventing it forever.

Persuasion and Pugnacity

Semmelweis had solved the great medical mystery of his life. He knew exactly what caused childbed fever and how to prevent it. But the work of a detective is not only the mental discovery of who committed a crime. After identifying who committed a crime, a detective must also seek the culprit out and bring him to justice. For Semmelweis, after convincing himself that he had determined the cause of childbed fever, he had to ensure that hospitals around the world were requiring doctors and staff to wash their hands and equipment with chlorine before every examination. Semmelweis spent the last 18 years of his life working with all his might to make this happen.

In this great, decades-long effort, Semmelweis was mostly unsuccessful. His supervisor later rescinded the chlorine-washing policy he had instituted in his clinic, and it was never reinstated again during Semmelweis's life. Ten years after his discovery, his successor as First Assistant in the clinic wrote that his theory had been "almost unanimously rejected" throughout all of Europe.

Even after pioneering his great breakthrough, Semmelweis was struggling to hold down a job. His supervisor felt threatened by him and terminated his assistantship early. In other words, he was fired again. Wanting to continue his work, he applied to a "private docent" position at the same clinic. The docent position would make him a teacher with access to the clinic as well as its patients and its detailed records. His supervisor made him wait for a year, then turned him down again. Semmelweis had been fired multiple times in his short career, an astounding fact given how talented and diligent he was.

After getting fired multiple times, having his disinfecting policy rescinded, and realizing that he wouldn't be able to succeed in his career in Vienna, Semmelweis returned to his hometown Budapest, a "broken man." He offered to be a pro bono obstetrician for a local hospital, a voluntary position that he held for six years. The extent and duration of his pro bono work shows that his great dedication to his cause wasn't motivated by a desire for riches or glory. He truly wanted to save lives and help people. Eventually, he also took up private paid work on the side to earn money to support his family. After a few years in Budapest, he was hired to be a professor at the University of Pest. These years were extremely busy for Semmelweis, as he was trying to convince all of Europe of his theory of childbed fever while simultaneously feeding his family, saving lives at his clinic and attending to the bureaucracy and duties of an academic job.

At one point, his Budapest clinic experienced a rash of childbed fever cases. Semmelweis had been requiring staff to wash their hands in chlorine, but the fever continued to take lives anyway. He realized that the problem was with the sheets that were being used on the hospital beds. A hospital bureaucrat named von Tanden had hired an outside firm to wash their sheets. But von Tanden's budget was so low, he had to hire the lowest bidder for the job, and the washing was extremely unsatisfactory. Blood and tissue would remain on the sheets even after being returned from the "washing." The blood that hadn't been washed off of the sheets contained rotting tissues and bacteria that were causing childbed fever.

When Semmelweis noticed the filth of the sheets and the deaths they were causing, he was outraged. After spending years learning how to prevent childbed fever, a budget concern and a lazy laundry service was threatening to bring the disease back into his clinic and his life. He immediately gathered a pile of soiled, bloody sheets that had supposedly been washed, carried them to von Tanden's office, and threw them on von Tanden's desk to demonstrate how unacceptable the situation was.

Throwing bloody sheets onto a colleague's desk is the type of dramatic gesture that works in Hollywood movies. But in real life, it almost always leads people to be nothing more than annoyed and offended. Much of the time, it's better to simply have a civil conversation about budgets and laundry services rather than making dramatic gestures with soiled sheets. Remarkably, this gesture worked, and von Tanden immediately ensured that a better laundry service was hired to keep the sheets clean. But Semmelweis's combative and occasionally pugnacious gestures like this were not always so successful, and sometimes they led him to make enemies.

Whenever the ideas of a great genius are rejected, it's natural to wonder why. Since we see Semmelweis as a genius today, why didn't his contemporaries agree? People have speculated about the reasons for opposition to Semmelweis's claims for many decades.

The incident with von Tanden and the laundry could provide one explanation for why Semmelweis was not always able to convince his colleagues of his ideas. When trying to persuade others, it's important to do it in a diplomatic and savvy way. But Semmelweis was often pugnacious and impolitic. Others noted that he used "autocratic" imposition to implement his policies. His pugnacity and lack of desire to cultivate influential friends could have caused his ideas to fail to catch on.

Another reason for opposition to Semmelweis's claims could be that admitting that Semmelweis was right would lead to embarrassment. Well-meaning doctors would have felt mortified if they had been forced to admit that they and their shamefully unclean hands had been the cause of countless deaths over their careers. Hospital administrators all too often would rather ignore mortality rates that made them look bad.

Other reasons for opposition to Semmelweis's claims are more prosaic. For example, there is always inertia in any body of theory or any practice. Doctors learn something in medical school in their twenties, and may go on believing it until they die eighty years later, even if others try mightily to change their minds with strong evidence. This kind of stubborn inertia is why Einstein once said that science progresses "one funeral at a time."

Semmelweis was hurt every time someone rejected his theories. But he never gave up, and his obsessiveness gave him great power. He didn't merely believe the truth, but, as one biographer put it, he was willing to not only "fight for its truth but vouch for it with his life." He regarded all childbed fever deaths as unnecessary, and described his motivation for writing a book about his theories: "indignation at the greatness of this scandal has thrust the pen into my unwilling hand."

In the years that Semmelweis spent trying to convince others about his ideas, he used many methods to spread his theory: public speeches, articles in scientific journals, policy changes in hospitals, private conversations, a book, and open letters to his enemies. As the years went on, Semmelweis became increasingly confident about his beliefs, increasingly exasperated that they weren't widely adopted, and increasingly impolitic in his efforts to spread his ideas far and wide. In 1860, he wrote a book describing all of his efforts and ideas, and distributed it throughout Europe. Even though the book laid out all the evidence clearly, he wasn't believed by the majority of doctors.

Eventually he began writing open letters to his enemies, describing why he believed he was right and they were wrong. But his exasperation made the letters difficult to read, and almost entirely ineffectual. Consider the following excerpt from a long letter to one of his enemies (in which Semmelweis uses the word "puerperal" to mean "related to childbed fever"):

"Herr Professor, I believe that your mind has not been sufficiently lighted by the Puerperal Sun, which rose in Vienna in 1847. . . . In [this] massacre, you, Herr Professor, have participated.... There is no other course open to me except to keep watch, at every man who dare spread dangerous errors.... This homicide must stop."

These are strong words - particularly the accusation that his enemy was participating in a homicide. In another letter, he described a different enemy as a "medical Nero." Of course, none of his enemies were receptive to this idea - they were doctors, after all, dedicated, however imperfectly, to saving lives. Hospital administrators like Johann Klein, the man who fired Semmelweis and failed to implement his chlorine hand-washing policy, were not holding a gun and committing cold blooded murder in the way we usually think of it. But from Semmelweis's point of view, they were similar to what Hannah Arendt later called "desk murderers," the Nazi bureaucrats who ordered killing from their desks without ever pulling a literal trigger.

Some of Semmelweis's enemies must have thought of themselves as nine-to-five bureaucrats just doing their jobs. If a few people died during their workday, they forced themselves to shrug and forget about it and focus on enjoying their lives outside of work. Semmelweis was not able to live like that. Knowing that people were dying every day who could have been saved tortured him and made him act in this fanatical way. Semmelweis thought of his complacent enemies as monsters who could easily stop countless murders but failed to do so because of the homicidal evil in their hearts. True as this may have been, it didn't win him friends or help him influence people.

Semmelweis was consumed by his passion for ending the scourge of childbed fever. At one point, he even stood on the side of the street and gave an impromptu oration to random strangers passing by about his theories. He was mocked for this, and people even called him "Pester Narr" (the fool of Budapest) for his crackpot-like behavior. But who is the real crackpot - the man who understands disease and wants to take a small step to save countless lives, or the complacent people who let others die through their lazy inaction and incorrect beliefs? Imagine if you knew a secret that could save thousands of lives every day. Wouldn't it be a sin or a shame to keep it to yourself instead of telling everyone all the time? Semmelweis clearly felt that it was, and we can admire the purity and nobility of his beliefs, even as we mourn that he wasn't able to more successfully spread them.

The Turning Tide

Semmelweis didn't fail completely at his goal of convincing others. During the 18 years that he spent trying to convince doctors about his ideas, there were some notable successes. As early as 1851, one of Semmelweis's friends, F.H. Arneth, delivered an address to the Edinburgh Medico-Chirurgical Society in which he described Semmelweis's work and ideas in highly positive terms. In 1863, a professor in St. Petersburg wrote a complimentary letter to Semmelweis, describing his colleagues'

acceptance of Semmelweis's theories, and writing that "you will see from this how many followers you have in the Far North, and how strongly the younger men support you."

These small successes were part of a slowly turning tide. A few decades later, Louis Pasteur's work would establish bacteriology as a new, viable field of medicine with the potential to completely change the world's understanding of disease. In England, John Snow did his own data analysis that would also help turn the tide by establishing contaminated water wells, not city-wide atmospheric conditions, as the cause of cholera epidemics. Semmelweis saw some hints of the tide turning in his later years, but he wouldn't live to see any broad acceptance of his work, and the end of his life was tragic.

The fatigue of Semmelweis's long, hard years of work was taking its toll. He remarked at one point that repeatedly answering the same objections about his theories, over and over again, felt debilitating. But he was never one who shirked his duties. Even in the last months of his life, he was in charge of his university's payroll accounting, a tedious service that he was constantly asking to be relieved of, to no avail. Just like he was true to his duty of administering the company's payroll, he must have felt a similar duty to spread his medical ideas far and wide.

Eventually, the fatigue and exasperation of his efforts became too much for Semmelweis. Near the end of his life, his friends and colleagues noticed that his behavior was increasingly erratic. He started to drink more and spend improvidently. Sometimes his conversation didn't make sense, and his moods were dramatic and unpredictable. People started to believe that he was losing his mind.

After his behavior became intolerably disruptive to his family and friends, some of his colleagues took action. A doctor named Bokai wrote a psychiatric evaluation of him, certifying that he was mentally ill. With his wife's cooperation, they told him that they wanted to take him on a trip to a spa to have a break and feel better. But in fact they took him to an asylum - the Lower Austrian Mental Asylum, one of the worst medical institutions in Europe.

The psychiatric evaluation that led him to be committed to an asylum contained a reminder of the peril of his obsessiveness. Bokai describes Semmelweis's character as follows:

"...he defended his scientific views with a passion bordering on fanaticism, but with continual consistency in his opinion and motivation. He had a predilection for bringing up the theme of the etiology of childbed fever in medical circles, and while discussing it he could never rein in his passion and would not bear contradiction. He viewed every[one who raised a] contradiction as his enemy..."

The inner determination that had pushed Semmelweis to work so hard at his lifelong mission was now being used as evidence to get him committed to an asylum.

It seems unthinkable that a great genius and hero like Semmelweis could be committed to an asylum, and one of the worst ones in the Austrian empire at that. His commitment to the asylum is an appalling reminder of the difficulty the world has in understanding, accepting, and respecting great scientific revolutionaries. Those who are too far ahead of their times are ignored and rejected, or worse, persecuted and even killed for their ideas.

Semmelweis was only at the asylum for two weeks. He received only one visitor during his time there - one of his old mentors, Josef Skoda. He died in 1865, only two weeks after being committed. Semmelweis had grown up Catholic and had a brother who was a Catholic priest. Nevertheless, the asylum did not make arrangements for a priest to administer last rites before his death.

Over the centuries since Semmelweis's death, biographers have speculated a great deal about the causes of his final mental instability as well as his death. Many have speculated that he had contracted neurosyphilis, which could have caused him to deteriorate mentally. The biographer Obenchain has argued that he suffered from manic-depressive psychosis which became worse during his later years, then sepsis in the last months of his life. Both neurosyphilis and sepsis could have been causes of his death. Recently uncovered documents indicate that there were other potential causes of death. Evidently, asylum staff gave him severe beatings that must have hastened his demise if they didn't directly cause it.

His funeral had almost no attendees. His wife never visited him in the asylum, and didn't attend his funeral, later claiming that she had been bedridden with a young, sick child at the time.

Semmelweis's work was bright and glorious, but the end of his life was dark and miserable. Long years of hard work had never been properly appreciated, and he died in squalor. We must hope that Semmelweis had an idea of the good that his work had done, and the good it would do. Indeed, the epilogue of his book about childbed fever describes his feeling upon considering the future.

"When, with my current convictions, I look into the past, I can endure the miseries to which I have been subjected only by looking at the same time into the future; I see a time when only cases of self-infection will occur in the maternity hospitals of the world. In comparison with the great numbers thus to be saved in the future, the number of patients saved by my students and by me is insignificant."

Semmelweis always felt that fate had selected him for his life's work. All too often, those who are fated to do great works are not also fated to enjoy the great rewards their work deserves. The world at large, including all of us today, are the beneficiaries of Semmelweis's hard work and insights, his persuasion and pugnacity, and the tide he would turn that would lift up the whole medical world and all of us who are alive today.

Life Lessons from a Crackpot

Semmelweis was always an outsider, and very often misunderstood. As a youth, he was a German speaker in Hungary - outside of the main linguistic and ethnic group of his hometown. As a fresh medical graduate, he was rejected from his dream career of forensic pathology and had to observe it from the outside. He was fired from his obstetrics job and was never able to join the highest ranks of the social world of the top physicians of his day. Late in life, the rejection and mockery his theories faced made him an outsider from the whole world of academic medicine. But being an outsider, even a misunderstood, rejected outsider, didn't stop him from making a great breakthrough and changing the worldwide history of science.

In fact, all of his failures and rejections in some way helped nudge him closer to his eventual greatness. Being rejected from pathology pushed him towards obstetrics, where he would save countless lives and make a permanent mark on the world. His failure to be accepted at the top level of the social world meant that he had nothing to lose: he could expound on his theories forthrightly without any regard for sparing anyone's feelings. Being an outsider meant he never had to worry much about losing his prestigious social position, because he never had much of a prestigious social position to lose. From Semmelweis, we can learn that status as an outsider can even be helpful on the path to achieving greatness.

In the life of Semmelweis, we can see the power of obsession. If Semmelweis had not been obsessed with forensic pathology, he might never have gained the expertise to understand childbed fever on a deep level. If he had not been obsessed with finding the cause of childbed fever, he might never have dug through old statistical records and autopsy reports that gave him the clues he needed to solve the mystery. If he had not been obsessed with spreading his ideas far and wide around the world for decades, he might have been more completely ignored, and the tide of scientific history may have taken decades longer to turn towards the truth. His life is an inspiration to all of us to continue working obsessively on important projects, even after being repeatedly fired and rejected for decades.

Another contributor to Semmelweis's success was his keen power of observation. When his patients died, he didn't just go home and forget about it - he thought deeply about the symptoms and disease of each patient, and carefully read autopsy notes to try to find clues. When Kolletschka died, he didn't just mourn a friend - he observed every aspect of the autopsy and thought deeply about how it related to the cases he had witnessed before. From Semmelweis, we can learn that the clues we need to solve the mysteries we encounter in our own lives are surrounding us all the time, if we're careful and thoughtful enough to observe and interpret them.

Finally, Semmelweis's life teaches us never to complacently accept the worst parts of the world. If people are suffering and dying unnecessarily, we can do more than just shrug it off and ignore it, like the bureaucrats who ignored and rejected Semmelweis.

Semmelweis was deeply affected by every patient's death, and this sensitivity motivated him to work tirelessly to change the world.

But Semmelweis's life also shows us the peril of obsession. The deep urgency he felt to publicize his theories pushed him forward, but it also tortured him. His constant work led to great fatigue and frustration for many years, and separated him from his young children as they were growing. His work improved the world, but it didn't seem to ever make him happy.

Semmelweis could have chosen to live his life in many different ways. He could have been a social climber, not worrying much about deaths and diagnoses as long as he could have a successful career. He could have been a rich man, inheriting his father's grocery business or becoming a military judge and collecting gold and estates throughout the empire. But his interest in science, his desire to help others, his purity and uprightness, his keen intellect, the stubborn pugnacity of his personality, the vicissitudes of random chance, and the inscrutable hand of Fate, all led him to a different life: the life of a crackpot. This life caused him misery and tragedy, but it also led him to save countless lives all over the world, and to change the course of scientific history forever.