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CHAPTER 1

Gregor Johann Mendel

The Father of Genetics

It is 1854. In the low hills just outside the Moravian capital, Brüun, there is a monastery with whitewashed brick walls surrounding gardens, courtyards, and buildings that are chilly even in summer. The fortresslike walls were built to protect its original inhabitants, Cistercian nuns, who took up residence in 1322. The nuns departed late in the eighteenth century, and the monastery lay empty for a while, falling into disrepair. It was taken over by a community of Augustinian monks in 1793—they had been displaced from the ornate building they occupied in the center of Brüun because Emperor Franz Josef of the Austro-Hungarian Empire wanted their jewel of a building for his own residence and offices.

By 1854, the monastery of St. Thomas had been headed by Abbot Cyrill Napp for several years. Within the Catholic Church, the Augustinian order had a reputation for liberalism, and Abbot Napp was particularly forward-looking. Born into a wealthy local family, he had very good connections with the leaders of secular society in Moravia, which were useful when the more conservative local bishop objected to the extent of the research taking place at the monastery. Since 1827, Napp had even been president of the prestigious Royal and Imperial Moravian Society for the Improvement of Agriculture, Natural Science and Knowledge of the Country (popularly, the Agriculture Society), which had been founded in 1807, the same year that Emperor Franz I had decreed that the monks of St. Thomas and other local monasteries would teach both religion and mathematics at the city's own Philosophical Institute. Among the monks at St. Thomas there was one for whom Abbott Napp had a particular fondness, even though—or perhaps because—he was something of a problem. That monk was Gregor Johann Mendel, and in 1854, with Napp's blessing, he began an experiment with garden peas that would ultimately prove to be one of the greatest scientific breakthroughs in a century filled with them, providing the basis for what we now call *the science of genetics.*

On the surface, there was little about Gregor Johann Mendel's life to suggest that he was remarkable. There were oddities about it, but they appeared to indicate weaknesses rather than strengths. Born in 1822, the middle child and only boy in a family that also included two girls, he grew up on a farm in Moravia, then under Austrian rule but now part of the Czech Republic. (Brüun is now known by its Czech name, Brno.) His father Anton was extremely hard-working and tended toward dourness, a trait even more pronounced in his older daughter, Veronika. His wife, Rosine, and the younger daughter, Theresia, were both of a contrasting sunny disposition. Gregor (who was christened Johann and assigned the name Gregor when he later became a monk) alternated between his father's pessimism and his mother's cheerfulness. Families everywhere, then as now, exhibit character traits that appear to have been passed down from parent to child, but in the twenty-first century we recognize that some of those qualities of personality and mind-set are a matter of genetic inheritance. Gregor Mendel himself would establish the first scientific basis for that understanding, only to have his work ignored in his lifetime and for fifteen years beyond it.

Gregor was a bright child, and ambitious. As a teenager, he wrote a poem in celebration of the inventor of movable type, Johann Gutenberg, which concluded with lines expressing hope that he, too, might attain the "earthly ecstasy" of seeing ". . . when I arise from the tomb/ my art thriving peacefully/ among those who are to come after me." There were impediments to any such grandiose achievement, however. The family's financial resources were modest, which would make it difficult to obtain a higher education. In addition, he was subject to periodic bouts of a psychosomatic illness that would keep him in bed for weeks at a time. His father and older sister had little patience with this kind of behavior, but his mother and younger sister indulged him. Theresia went so far as to give him her share of the meager family estate, which should have been her dowry, so that after graduating from the gymnasium (secondary school) he could go to the Philosophical Institute in the Czech-speaking town of Olomouc, a two-year program required of all students who wished to study at a university.

His sister's sacrifice would be repaid in later years, when he assisted her, financially and otherwise, in the raising of her three sons, two of whom would become physicians thanks to the help of their uncle. Yet even with his sister's loan, it was clear that there would not be enough money to attend university. Neither a modest scholarship grant nor his own efforts to earn money by tutoring would add up to sufficient resources. There was only one path open to him if he wanted a further education: he must become a monk.

Mendel was fortunate to have a physics professor at the Philosophical Institute, Friedrich Franz, who was himself a monk and an old friend of Abbot Napp at the monastery of St. Thomas. Even though Franz could muster only a modest recommendation concerning Mendel's intellectual ability, Napp agreed to take him in. Mendel arrived at St. Thomas in 1843, at the age of twenty, and spent the next five years studying to become a priest, starting as a novice and then moving up to subdeacon and deacon. He was moved through these steps more rapidly than would ordinarily have been the case, for the simple reason that the monastery had a shortage of priests. As Robin Marantz Henig explains in her book *The Monk in the Garden,* a number of monks who had administered last rights to patients at nearby St. Anne's Hospital had contracted fatal diseases themselves. Mendel was ordained as a priest two weeks after his twenty-fifth birthday, on August 6, 1847, and spent another year completing his studies before taking up pastoral duties. It quickly became apparent that he was far too shy and uncertain of himself to deal with parishioners. Indeed, he once again took to his bed, seriously ill without being sick. Abbot Napp decided that Mendel would be more usefully and successfully employed as a teacher, and the local bishop somewhat reluctantly sent him south to Znojmo to become an instructor in elementary mathematics and Greek at the secular gymnasium in that ancient town.

Mendel's year of teaching was a success. The discomfort he felt with adults he didn't know well, which had made pastoral duty so onerous, didn't affect him in dealing with youngsters, and he was also well regarded by his fellow teachers. He now had hopes of becoming a fully accredited high school science teacher. But in 1850, he failed the written and oral tests necessary for accreditation. Mendel's biographers have speculated at length about the reasons for this collapse. Part of the problem seems to have been a kind of "performance anxiety," no doubt connected to his tendency to psychosomatic illness. But there is also evidence that he sometimes refused to give the expected answers because he disagreed with current beliefs on a variety of subjects. In addition, there was a scheduling mix-up that meant the professors administering his oral exam had to meet on a date when they had expected to be free to travel, putting them in a foul mood. Six years later, however, when he tried again, his performance was even more dismal, and he seems to have simply given up after getting into an argument about an early question. What made this second failure profoundly discouraging was that he had spent two of the intervening years studying at the university in Vienna.

Mendel would continue teaching at the grade school level for a number of years, but his failure to gain more substantial academic credits underscores some important points about the nature of scientific amateurism. As we will see throughout this book, great amateur scientists have often received a considerable amount of education, but it tends to be spotty and sometimes lacking, ironically, in the very area in which the scientist ultimately makes his or her mark. In Mendel's case, he received more mathematics training than anything else, and that would make it possible for him to apply a mathematical rigor to his experiments with pea plants that was highly unusual for the period. He also studied some botany, but this was a subject that caused him particular problems. Because he was a farm boy, he had an ingrained knowledge of plants that caused him to balk at various academic formulations. When a student refuses to give the answer he or she has been taught, academicians inevitably conclude that the student is stupid rather than reassess their own beliefs. Brilliant amateurs have always been prone to question the questioner, and that usually gets them into deep trouble.

The end result is often a young person of great talent who has not attained the kind of academic degree or standing that would serve as protection when he or she puts forward an unorthodox idea. Even the attainment of academic excellence may not be enough to stave off attacks from establishment scientists; without such achievements, new concepts are likely to be utterly dismissed. There is another side to this coin, however. If Gregor Mendel had in fact passed the tests that would have made him a full-time high school teacher, it is unlikely that he would have had the time to devote to the experiments that would eventually make his name immortal.

Between attempts to gain accreditation, Mendel also began his first experiment in heredity, which predated his efforts with peas.

He was allowed to keep cages of mice in his quarters, and bred wild mice with captive albinos in order to see what color successive generations would turn out to be. Selective breeding of both animals and plants had been practiced for centuries by farmers like his father, but even though a farmer might succeed in improving the strength of his animals and the hardiness of his plants, no one had any idea why or how such improvements occurred. Mendel wanted to know exactly that. Although the Catholic Church now recognized the importance of scientific inquiry in general, not all its leaders were happy about this trend. It was true that the Church had embarrassed itself in forcing Galileo to recant his belief in the Copernican model of the solar system in 1638 (an apology was finally issued by Pope John Paul II in 1998), and had gradually found ways to reconcile scientific progress with its theology, but there were some who found it unseemly for members of the priesthood to be involved in such matters. One of those who took a dim view of scientific research was the local bishop, Anton Ernst Schaffgotsch. He was more or less at war with Abbot Napp for many years, but the abbot had too many prominent local friends, and his monks were too highly regarded as teachers, for the bishop to get away with closing down the monastery, as he would have liked. Nevertheless, he was able to set some limits, and during one confrontation with Napp he decreed that Mendel's mice had to go. He was particularly disturbed that sexual congress was at the heart of the monk's experiments.

Without knowing it, the bishop actually did Mendel a great favor. While mice were regarded as very simple creatures with obnoxious habits, they are in fact genetically complex. We now know them to be biologically similar to humans in many ways, which is one reason why they are so often used in medical experiments. If Mendel had continued to experiment solely with mice, it would have been impossible for him to achieve the breakthrough he did. The very complexity of the creatures would have derailed his project.

And so, in 1854, Mendel turned to the common pea. There had been an experimental garden at the monastery for more than two decades, and such work was seen as a potential benefit to agriculture in general, and far more seemly than breeding generations of animals. Mendel is reputed to have commented, with amusement, that the bishop failed to grasp that plants also had sex lives. The reproductive mechanisms of plants are in fact quite varied. Some species have specifically male and specifically female plants. If the gardener does not make sure to have a male and a female holly bush, for example, and to plant them near one another, there will be no berries. A great many plants depend upon bees for pollination—if the bee population is destroyed in a locale, numerous plants will die out, having no way to reproduce. The common garden pea, the species *Pisum,* that Mendel experimented with would survive the loss of the bee population, however, since they are hermaphroditic, each flower containing both the male *stamen* and the female *pistil.*

The fact that peas are hermaphroditic was important to Mendel's experiments, because it made it possible for him to exercise complete control over their reproduction. Such control did require a great deal of painstaking work. The yellow pollen that contains the male gamete (sperm) is produced in the tiny bulbous anther at the top of each antenna-like stamen. Under usual circumstances, the pollen will fall onto the sticky stigma of the female pistil, and pass down the canal known as the style to the ovules (eggs). In order to crossbreed different pea plants, the monk had to proceed slowly down a row and remove the pollen by hand from the stamens of plants he wanted to fertilize with the pollen of another. He was in effect castrating each plant on which he carried out this operation. He would then cover the buds with tiny caps of calico cloth, to protect them for the few days it would take for the female stigma to mature and become sticky. The cap also prevented any insects from fertilizing a castrated plant with the pollen from still another plant. When the stigma was mature, Mendel would pollinate it with the gametes gathered from another plant with different characteristics.

We do not know how Mendel kept track of what he was doing. No logbooks or notes exist, only the final paper he would present to the Agriculture Society in two sections, a month apart, in 1865, which was then published by the Society. All his other papers were burned in the courtyard of the monastery following his death—but that is getting ahead of the story.

What we do know from the 1865 paper reveals an extremely orderly mind, and an entirely new way of categorizing the results of crossbreeding experiments. There is a language problem that needs to be cleared up before we look at the experiments in more detail, however. In Mendel's day, crossing any organism with another was called hybridization. No distinction was made between crossing organisms of two different species and crossing organisms that were merely different varieties of the same species. Mendel's two-part paper of 1865 was titled "Elements in Plant Hybridization," but today that title would be regarded as incorrect, since he was in most cases crossing varieties of the same species of peas. Today, the creation of a true hybrid is defined as the crossing of different species, as the tangerine and the grapefruit were crossed to create the tangelo. Among animals, a mule is a hybrid of a horse and a donkey, and the mule is sterile, as is often the case with hybrids, although in plant hybridization fertility can be restored by chemical treatment that doubles the chromosomes.

Mendel's work did not suffer from the confusion surrounding the meaning of hybridization, however. He determined that garden peas had seven distinct characteristics, or traits, that were always exhibited in one of two ways, as can be seen in the following chart.

The Seven Traits of Pea Plants

TRAIT	VARIETY
Seed shape	Smooth or wrinkled (alternatively round or angular)
Seed color	Yellow or green
Seed coat color	White or gray
Stem length	Tall or short
Shape when ripe	Pods inflated or constricted
Color of unripe pods	Green or yellow
Position of flowers	All along stem or single at top of stem

There are a few aspects of this list that require special comment. Many books use only the descriptions "smooth" and "wrinkled" in respect to seed shape. But as Henig makes clear in *The Monk in the Garden*, neither smoothness nor being wrinkled are really a matter of shape. In her view, and that of other specialists, a mistranslation from the German is at fault, and what Mendel was really looking at were actual shapes, round and angular. In addition, the third characteristic, seed coat color, sometimes appears as flower color. He did start out with flower color, but apparently realized that flower color was linked to other characteristics, and thus added, and paid special attention to, the color of the seed coat. We now know that each of the seven traits listed above, including the white or gray color of the thin translucent seed coat, is determined by a separate chromosome and transmitted independently.

Before starting to cross different varieties of pea plants, Mendel spent two years growing plants from the seeds produced by each variety. This was done to make certain that all the plants he was using were "true," and would not produce any variations on their own. The fact that he spent so much time laying a rigorous foundation for his experiments is one of the reasons his work has come to be so highly regarded. Many people might think this was a boring prelude to the experiments to come, but Mendel took so much pleasure in gardening for its own sake that even this preliminary stage must have brought its satisfactions.

Once he was certain that the plants were stable down through several generations, he began crossing plants carrying each of the seven traits with other plants carrying the opposite trait. Plants that produced round seeds were crossed with plants bearing angular seeds, tall plants with short ones, single-flower stems with multiple-flower stems. At the time it was believed that heredity was always a matter of a balance being struck—thus the crossing of a tall plant with a short one would be expected to produce a medium height plant. But that was not what happened. The crossing of a tall plant with a short one always produced tall plants in the next generation. Nor did the crossing of plants with yellow pods and plants with green pods produce a new generation that was a greenish-yellow blend—instead the pods were all green. From these results, which held true for all seven traits, Mendel came to the conclusion that some "factors," as he called them, were stronger than others. The stronger factor he called *dominant*, the weaker factor he called *recessive*. Those two terms are still in use today, a tribute to their aptness and to Mendel's genius. He did not know what the factors themselves were, however—it would not be until 1909 that the Danish professor of plant physiology Wilhelm Johannsen coined the word *gene* to describe these factors, and it would take until the 1940s to determine that genes could be identified with a particular length of DNA, the complex molecule that contains the chemically coded information necessary to make proteins.

Year after year during the remainder of the 1850s and on into the next decade, Mendel crossed his pea plants. Some he certainly grew outdoors in warm weather, but others must have been raised in colder months in the two-room glasshouse in the monastery courtyard next to the brewery, and later in the greenhouse that was built on the orders of Abbot Napp for Mendel's particular use. The small glasshouse was heated by a stove, but the larger greenhouse, erected in a sunnier location, was warmed only by the heat of the sun. Robin Marantz Henig relates in great detail the arguments that developed in the twentieth century about the exact location of the outdoor garden where Mendel grew his peas. Those arguments occurred because the officially designated plot seemed too small and too shady to have sustained all the plants Mendel said he had grown. This constricted, sun-deprived plot of land seemed to some doubters evidence that Mendel had lied about the extent of his research. Only in the 1990s years did extensive scholarly detective work establish a larger, sunnier plot of land by the greenhouse as the location of his main garden. The clue that solved the mystery revolved around which windows his fellow monks would call out to him from as he worked with his pea plants. It was long assumed that they had greeted him from the windows of the formal library that overlooks the smaller plot, but in fact the monks spent most of their time in the study rooms at the far end of the structure, where the windows opened onto an entirely different part of the grounds.

After Mendel had tested many generations of pea plants following the initial crossing for each of the seven traits, he moved on to cross these plants again. He expected this double crossing to once again affirm the strength of the dominant factors, including tallness and green pods. To his astonishment, that was not the result. Some of the plants turned out as expected, but others did not. A lesser man might have thrown up his hands in despair at this point. Was his theory about dominant and recessive genes incorrect, after all? But the monk had been putting his mathematical training to use from the start, and now those carefully kept figures revealed an even greater secret. Again and again, the new plants produced a 3:1 ratio—for every three plants that did retain the dominant gene, one did not. This ratio held true for all seven traits. Such a ratio could not be mere accident. Something profoundly ordered was at work, and Mendel's 3:1 ratio would become the basis for the work of hundreds of twentieth-century scientists seeking to unravel the full story of the genetic code of living organisms, including human beings.

Mendel was not working in a complete vacuum as he carried out his experiments on pea plants. In the 1730s, the Swedish botanist Carl von Linné, writing under the Latinized name Carolus Linnaeus—by which he is primarily known today—created a system for categorizing all living things, divided into two "kingdoms," plant life and animal life. Within each kingdom, organisms were subdivided, in descending order from the broadest to the most specific groups, into classes, orders, genera, species, and finally the varieties within a species. This system has become more complicated with the development of further knowledge, so that we now have five kingdoms instead of two, and a phylum (for animals) or a division (for plants) that precedes the class. There are also possible subclasses, which precede the order, and families, which precede (and sometimes coincide with) the species. Human beings belong to the chordate kingdom, the mammalian phylum, the primate class, the hominid order, and the family/species homo sapiens. Even with the less complex system devised by Linnaeus, however, the seeming chaos of nature was given shape in a way that made it possible for anyone, whether knowledgeable amateur or professional scientist, to understand exactly what plant or animal was being described.

Yet Mendel did not in fact know the exact classifications of his peas. They were all common garden peas, of the genus *Pisum,* some already growing in the monastery garden and some that he sent away for. He believed that most were *Pisum sativum*, although experts suspect that some other species aside from *sativum* were among his specimens, such as *Pisum quadratum*. Mendel was a bit cavalier about this question, feeling that in terms of what he was interested in doing, it didn't much matter provided he made certain at the beginning that each plant bred true. His lack of concern about the exact species of each plant was not surprising—he had gotten into trouble on his exams about precisely this kind of detail. But he was correct—it did not really matter in respect to his particular experiments. A more "professional" or academic scientist might well have gotten hung up on the fact that the exact species of each plant was not known, but Mendel's "amateurism" in regard to this matter allowed him to proceed enthusiastically with the more crucial two-year testing period to make sure each plant bred true generation after generation. Amateurs can get things terribly wrong by ignoring "academic" details, but the brilliant amateur can sometimes vault over a problem by virtue of his or her recognition that the "correct" way of proceeding may not be necessary in a given situation.

When Mendel began his experiments, there was also a great deal of ferment about the subject of transmutation, which would soon come to be called *evolution*. This hubbub had begun in 1809, with the publication of a book by the French naturalist Jean Baptiste de Lamarck titled *Philosophie zoologique*. Lamarck coined the word *biology* and was the first to distinguish vertebrate from invertebrate animals (leading to a major addition to the categories devised by Linnaeus). But his reputation suffers from the fact that his ideas about evolution turned out to very wrong, and were ultimately seen as ridiculous. He believed that plants and animals changed according to their environment, which was an accurate enough supposition, but his examples of how they changed now sound like the fables in Rudyard Kipling's *Just So Stories*, such as "How the Elephant Got His Trunk." No matter how flawed, though, his work proved a bombshell that appeared to call into question God's place in creating the creatures of the earth. The idea that one hungry giraffe stretched his neck to eat leaves that were seemingly out of reach higher up a tree, and that the results of such stretching would be instantly fixed, and thus passed on to the giraffe's offspring, seemed blasphemous rather than silly to the devout, including many scientists. Thus there was consternation regarding evolutionary concepts even before the publication of Charles Darwin's *Origin of Species* in 1859, when Mendel's own experiments were still four years short of completion. Darwin rejected Lamarck's ideas, being influenced instead by the economist Thomas Malthus's concept of a "struggle for existence," which he transformed into the "survival of the fittest." But because Darwin believed, in contrast to Lamarck, that change took place in plants and animals over very long periods of time, his work also flew in the face of biblical dogma concerning the creation. More blasphemy, according to many.

Mendel clearly became familiar with Darwin's work, since he would send him a copy of his two-part lecture on his pea crossings in 1865. But he managed to present his own work in a way that avoided direct entanglement in the great evolutionary debate. The implications of Mendel's experiments certainly had importance in terms of evolution, and he must have realized that they did, but his mathematical approach was so new and so dry that it obscured the controversy lying below the surface of his numbers. The truth is that virtually no one understood what he was doing. To the extent that his work seemed in any way remarkable to those who heard his lectures or read the published version, it was largely a matter of simple amazement that he could keep such close track of all those thousands of pea plants grown, generation after generation, over so long a period of time. "So much work—he must be quite clever," appears to have been the general reaction.

In the latter stages of his experiments, the work became even more complicated. He had established that the double and triple crossing of his plants would produce a 3:1 ratio between dominant and recessive factors. But to establish conclusively the nature of the dominant and recessive factors, it was necessary to take a further step, backcrossing his hybrids with original parent plants in two different ways. Half these crosses were made with double dominant plants, half with double recessive plants. He expected that the double dominant crosses would produce plants that were all alike in appearance—the dominant factor would be so strong as to mask any underlying recessive factor. On the other hand, the results from the double recessive crossings ought to be four different types in a 1:1:1:1 ratio, because the recessive factors would not be suppressed by any dominant ones, and would therefore resurface. That was exactly what happened.

It would be another half-century before the technical language would be developed to explain these results. But Mendel had clearly demonstrated the difference between a *phenotype* (in which the physical traits are visibly displayed) and a *genotype* (in which the gene variants are present, and still capable of being passed on to another generation, but are not necessarily visible). He had started with a theory and ended with confirmation of what eventually came to be called Mendel's laws. He went on to experiment for a couple of years with a variety of other plants, including snapdragons and maize, which appeared to show that the results he had achieved with his peas would hold true for any plant.

The pea experiments were concluded in the summer of 1863. That turned out to be extremely fortunate, since the next year almost all his pea plants were destroyed by the pea weevil. If that pest had shown up three or four years earlier, it would have been impossible to carry out his backcrosses of the double dominant and double recessive plants. Mendel's physical condition by 1863 was also making his work more difficult. His eyesight was getting poorer, and he was quite heavy—the latter the result of a monastery kitchen widely known for the excellence of its cook, Luise Ondrakova, who would eventually write a cookbook containing, among many soups, strudels, and pork dishes, her famous rose-hip sauce for meat.

For two years, Gregor Mendel worked on the paper describing his experiments. He delivered it in two parts, on Wednesday, February 8, and Wednesday, March 8, to the Brüun Agricultural Society. There are conflicting reports about its reception, but it was at the least polite. The society duly published the forty-four-page paper, and Mendel ordered forty copies of it, which he proceeded to send out to many of the most illustrious scientific names in Europe, including Charles Darwin. A number of these copies were found in later years, when Mendel's work was rediscovered. But at the time almost no one paid real attention. In those days, such publications arrived with the pages folded over. In order to read them, it was necessary to cut the pages. Darwin's copy, and some others, were not even cut. They had never been read by the recipients.

Mendel's dismay that there was no reaction from thirty-nine of the important scientists to whom he sent his paper was offset by what he considered the importance of the one reply he did get. When he was studying in Vienna, one of his teachers, Franz Unger, often praised the work of Karl von Nägeli, a professor of botany at the University of Munich. In 1842, Nägeli had described the processes of what we now call cell division and seed formation in flowering plants. Mendel became almost obsessed with Nägeli, and sent him a copy of his paper, together with an explanatory note, at the very end of 1866. It was two months before he received a skeptical reply—several drafts of which, we now know, had been composed by Nägeli. The professor held to the belief that crossbreeding produced a blend, and he appears to have recognized that if Mendel's experiments were correct, it would prove that view wrong. Thus he suggested that the experiments had not been carried far enough, and that even though they might be correct as far as they went, they did not provide sufficient justification for any general law. Mendel wrote back, trying to further clarify certain aspects of his paper. There was no answer to that letter, and Mendel tried a different approach in a third and then a fourth letter, finally suggesting that he could act as a kind of assistant to Nägeli in his own experiments, if the professor would send him some seeds to work with. That got a response, and the correspondence continued intermittently for seven years. Unfortunately, the seeds that were sent to Mendel were hawkweed (*Hiercium*), and crossbreeding them was fruitless, because hawkweed usually reproduced in a way that produced clones, called *apomixis* in plants and *parthogenesis* in animals. There is some question to this day about whether Nägeli knew he was giving Mendel an insoluble problem. The frustrating results, at any rate, even led the monk to question his own previous success with peas.

But Mendel would have less and less time for experiments anyway. On March 30, 1868, he was elected the new abbot of St. Thomas on a second ballot, succeeding Abbot Napp, who had just died at the age of seventy-five. He now had a great many administrative and social duties to occupy his time. As though to put a final exclamation point to his years of experiments, a freak tornado in October 1870 destroyed the greenhouse that had been built for him. He continued to serve as abbot until his death on January 6, 1884, but his standing in the community waned due to an endless tax dispute with the government.

Anselm Rambousek, whom Mendel had defeated in 1868, then became the new abbot, and soon saw to it that his predecessor's papers were burned. It would be another fifteen years before Mendel's work was rediscovered. His name was not unknown—he was listed fifteen times in Wilhelm Obers Focke's work on plant hybridizing, and because of those references, he was accorded a brief mention in the next edition of the *Encyclopedia Brittanica*. But neither publication made clear the significance of his work. That would have to wait until 1900, when three biologists almost simultaneously came across Mendel's original paper.

A botanist from Amsterdam, Hugo de Vries, was working along lines similar to Mendel's, but with different plants, when he came across the monk's paper, probably in 1899. Mendel's work backed up his own, but of course it also anticipated it by a quarter-century. De Vries made use of Mendel's terminology in a lecture but did not credit Mendel. The lecture was published and read on April 21, 1900, by his rival Karl Correns. Correns was also working on the question of hybrid relationships, and was infuriated by the fact that de Vries had once again beaten him to the punch, and not properly credited Mendel in the bargain. Correns happened to be married to a niece of Nägeli, and was able to gain access to the correspondence between the two men. The third rediscoverer, ironically, was the grandson of one of the professors, Eduard Frenzl, with whom Mendel had argued during his second failed attempt to gain accreditation as a high school science teacher. Young Eric von Tschermak published a paper in June 1900, in which he tried to anoint himself the true "rediscoverer" of Mendel, although many experts feel he never fully understood Mendel's work.

Correns wrote an essay of his own, titled "G. Mendel's Law Concerning the Behavior of the Progeny of Varietal Hybrids," in which he came close to accusing de Vries of plagiarism. Perhaps hearing about Correns's essay in advance, de Vries belatedly mentioned Mendel in a footnote added to a German translation of his lecture, but also tried to suggest that he had arrived at his own conclusions before coming across Mendel's thirty-five-year-old paper. The motivations of all three of these men have been debated ever since. Jealousy and self-aggrandizement certainly played their part, but as a result the name of Gregor Mendel was suddenly a very hot topic indeed.

In the end it was not any of these three men who would serve as the chief promoter of Mendel, however. That role was taken by a zoologist at St. John's College, Cambridge, who had turned thirty-nine in 1900, William Bateson. The historian Robert Olby has suggested that Bateson may have later fictionalized his own recognition of Mendel's genius, in order to make it more dramatic. He knew de Vries well, and would obviously have read his lecture—in the German translation that included the footnote mentioning Mendel's name—and there was a copy of Mendel's original 1866 paper in the Cambridge University library. But there are questions as to whether he could have gotten hold of Mendel's paper in time to read it, as he claimed, on a train ride to London on May 8, 1900. Bateson was supposed to give a lecture that day, and claimed to have revised it on the spot in light of reading Mendel's paper, but accounts of the actual lecture do not even mention Mendel. Nevertheless, Bateson did become Mendel's main champion.

Over the next several years, Mendel became the center of a bitter argument between two schools of thought. One school, following Darwin's lead, held that evolution occurred slowly, and in a continuous curve. Bateson believed that it occurred in discontinuous leaps, and that Mendel's laws showed how that could happen. The fight between these two groups continued for a decade, sometimes in the form of published papers, sometimes in public debates. In the midst of this scientific turmoil, Bateson invented the word *genetics,* although oddly enough, the word *gene,* to describe Mendel's "factors," did not come into use until several years later. The details of the debate between the Mendelians and the followers of Darwin, who were known as *biometricians,* are highly technical, but ultimately one major scientist after another came over to the side of the Mendelians, for many particular reasons and one general one: Gregor Mendel's laws proved to be the most useful and logical approach to the new science of genetics.

In his later years as the abbot of St. Thomas, when the subject of his pea experiments came up, Mendel sometimes said to friends, "My day will come." He said it gently, even humorously, by all accounts. He was not a man with a large ego. Those who would fight in his defense long after his death often had outsize egos, and reputations to protect, which meant that the debate could become extremely heated. The Moravian monk was an amateur who tended his rows of peas with unflagging devotion and care for nine years. Abbot Napp must have had some sense that the monk who could not pass his teaching exams or deal well with parishioners (at least in his younger years) had something very special to offer, or he would not have ordered the greenhouse to be built. But no knows whether Napp truly understood the importance of what Mendel was doing, or had any real inkling that the young monk was a genius.

Indeed, there have always been some scientists who have questioned whether Mendel deserves as much credit as he now gets. There have been claims that his results were too "perfect" and that he must have fudged the numbers. The long debate over the exact location of his garden—whether in the shade or in the full sun—was fueled by the annoyance of some scientists that a mere amateur should be credited with the foundation of a discipline that became one of the greatest success stories of the twentieth century and seems destined to be even more important in the twenty-first. DNA research, the ongoing effort to map the entire human genome, cloning, genetic modification of fetuses to banish inherited diseases and create more nearly perfect future humans—that all those headline-grabbing aspects of genetics should be traced back to a monk growing peas in a monastery garden is galling to some professionals. But any doubts have been overwhelmed by the fact that Mendel's laws hold true. A mere amateur began it all, while many of the great minds of his own time were on the wrong track. Rows of peas, in a sunny garden, in a special greenhouse, tended for nine years by an increasingly fat monk who all alone began a revolution in human knowledge.

To Investigate Further

Henig, Robin Marantz. *The Monk in the Garden*. New York: Houghton Mifflin, 2000. A National Book Critics Circle Award finalist, this is one of those rare books that manages to get the facts right and tell a scientific story with great charm at the same time.

Stern, Curt, and Eva R. Sherwood. *The Origin of Genetics: A Mendel Source Book*. San Francisco: W. H. Freeman, 1966. This volume contains translations of Mendel's paper, his correspondence with Nägeli, and other documents. It is regarded by many experts as the best translation of Mendel. Although out of print, it can be found in many libraries.

Orel, Vitezlav. *Gregor Mendel: The First Geneticist*. Oxford and London: Oxford University Press, 1996. This was the first major Mendel biography since 1926. Henig draws on it extensively, but her own book is probably the better bet for general readers.

Tagliaferro, Linda, and Mark V. Bloom. *The Complete Idiot's Guide to Decoding Your Genes.* New York: Alpha/Macmillan, 1999. For those who like to absorb complex subjects in small bites, this is an excellent overall introduction to genetics, with an early chapter on Mendel, and final ones that deal with modern controversies such as cloning.