CHAPTER 1

Pierre Curie

1859–1894

City workers in Paris removed a tree obscuring a view of Victor Hugo's home, placed baskets of flowers in front of it, decked the street with flags, and sanded it to prepare for a million marching feet. It was the writer's eightieth birthday in February 1881. Members of guilds carrying their banners gathered at the Arc de Triomphe before joining the enormous parade. The entire Sorbonne turned out, faculty and students. And each time the white-haired author appeared at his window he was greeted with a roar of approval.

In May of that same year, scientist and fellow Parisian Louis Pasteur achieved immortality and changed the course of medical history with a daring experiment on fifty sheep infected with the deadly anthrax. His successful work led to the birth of the sciences of immunology and bacteriology, whose advances have saved the lives of millions. Experiments were also under way in the Parisian art world. Claude Monet and Pierre Renoir, among others, tried to capture the effect of light on their subjects with short brush strokes and bright colors. Although critics dismissed their efforts as childish or myopic impressions of reality, the small band of artists pressed on to make the slur "impressionist" an accolade. No musician caused more of a stir in Paris at the time than Camille Saint-Saens, a short, ill-tempered dandy who spoke with a lisp and looked like a parrot. He composed operas, concertos, and symphonies, conducted orchestras, and gave piano and organ concerts. In his spare time he penned plays and poetry, and also studied astronomy, archaeology, and the occult.

Living in the same city as Hugo, Pasteur, Renoir, Monet, and Saint-Saens was a twenty-two-year-old physicist at the start of his career. Though Pierre Curie's achievements would eventually rival those of his remarkable compatriots in his own field, at that time he wondered if he could

keep his modest job as a lab assistant. It seemed unlikely, judging by an entry in his diary. And, if it was a clue to his character, he was certainly in the wrong profession. He sounded more like a poet in distress heading for a breakdown than an experimental scientist on the way up. "What shall I become?" he wrote. "Very rarely have I (complete) command of myself; ordinarily a part of me sleeps. My poor spirit, are you then so weak that you cannot control my body? Oh, my thoughts, you count indeed for very little! It seems to me that my mind gets clumsier every day. Before, I flung myself into scientific or other [diversions]; today they don't hold my interest. And I have so many, many things to do! Is my poor mind then so feeble that it cannot act upon my body? And Pride, Ambition—couldn't they at least propel me, or will they let me live like this? I should have the greatest confidence in the power of my imagination to pull myself out of this rut, but I greatly fear that my imagination is dead."

In her brief biography of Pierre, his widow, Marie, tried to explain this diary entry. She believed that when not fully engaged in scientific research he felt himself incomplete and became depressed. It was during such a time, she implied, that he made the diary entry. Yet his devastating self-analysis was recorded soon after he and his brother, Jacques, had made a scientific breakthrough. They had discovered that pressure on certain crystals produced electricity—later known as piezoelectricity. And their modus operandi had been reported by Jacques's teacher Charles Friedel at an Academy of Sciences meeting on August 2, 1880. Meanwhile the brothers were pursuing further research in piezoelectricity, which resulted in the publication of eight more papers on the subject. Yet it was during this time, while fully engaged in his work, that Pierre had expressed his fear of failure.

What a glaring contrast in confidence and spirit to both his father and his grandfather. His grandfather, Dr. Paul François Curie, had been a surgeon in the Military Hospital of Paris until he realized that conventional medicine killed as many as it cured—prompting him to leave France for England to pioneer a daring new system of healing, called homeopathy, in a London hospital. Homeopathy was a natural pharmaceutical science that made use of plants and minerals to stimulate the sick person's natural defenses. He gave his patients small doses of a medicine that in large doses would cause symptoms similar to those they were experiencing. Dr. Curie taught an Irishman, Joseph Kidd, to use the same method of healing. Kidd returned to Ireland during the potato famine of 1847 to give homeopathic

Pierre's grandfather, Paul François Curie, a political radical and a daring and enterprising physician, practiced homeopathic medicine in England.

treatment to those suffering from the fever and dysentery associated with starvation. "During 676 days he treated 111 cases with 108 cured, 1 dismissed, and 2 deaths—a mortality rate of 1.8% compared to the 13.8% mortality rate in the local hospital." Later, for several years Kidd was British prime minister Benjamin Disraeli's doctor.

A fervent practitioner, Dr. Paul Curie dedicated his book *Practice of Homeopathy* to fellow physicians and appealed to their scientific integrity to test the new treatment.

Pierre apparently had inherited none of his grandfather's enterprise, self-confidence, and commitment, nor did he inherit any of his father's drive and audacity. His quick-tempered, somewhat autocratic father, Eugène, was a man of action, with a scar to show for it. A bullet had shattered his jaw when, as a medical student at the Hôpital de la Pitié in Paris, during France's revolution of 1848, he took care of wounded rebels. He eagerly supported this successful insurrection against King Louis-Philippe, whose government of mostly noblemen had ignored the appalling conditions of the poor. The new republican government gave Eugène a medal for his honorable and courageous conduct. He again showed his mettle as a young doctor when a cholera epidemic broke out in Paris. Other doctors fled in panic, but Curie risked his life to go to the dreaded area and treat the victims.

His wife, Sophie Claire Depouilly, five years his junior, was the daughter of a once wealthy cloth manufacturer in Puteaux. When she was a teenager her father lost his fortune in a financial crisis brought on by the 1848

revolution. But she remained cheerful and optimistic, a loving wife and mother.

The Curies already had a three-year-old son, Jacques, when Pierre was born in Paris on May 15, 1859. Their house on the rue Cuvier overlooked the Jardin des Plantes, a sixty-acre complex of botanical gardens, a zoo, and the National Museum of Natural History, where for a time Dr. Curie worked in the laboratories. Jacques welcomed the newcomer to the family—and the brothers would become close, affectionate friends for life.

Convinced that Pierre was too sensitive and introspective for the rigid, highly structured atmosphere of a French classroom, his parents, and later his brother, taught him at home. Throughout the elementary and high school years they gave him a grounding in biology, chemistry, physics, and geometry. He made up for his lack of schooling in literature and history by reading many of the books in his father's large library. In her biography of her husband, Marie Curie explained why it would have been hopeless to send Pierre away to school: he could only learn a subject thoroughly by intense concentration, which he found impossible in a disturbing environment. "It is clear," she wrote, "that a mind of this kind can hold great future possibilities. But it is no less clear that no system of education can be especially provided by the public school for persons of this intellectual type. If, then, Pierre's earliest instruction was irregular and incomplete, it had the advantage of [freeing his mind from] dogmas, prejudices or preconceived ideas. And he was always grateful to his parents for this liberal attitude." Pierre called himself a slow thinker. Years later, Marie would be more generous. She believed that "Pierre's intellectual capacities were not those that would permit the rapid assimilation of a prescribed course of studies. His dreamer's spirit would not submit itself to the ordering of the intellectual effort imposed by the school." In other words, he would resist being told what to do and when to do it.

When Pierre was twelve, his father again supported the workers, this time in the uprising at the end of the Franco-German War (1870–1871), which Napoleon III had launched to boost his fading popularity. During the siege of Paris by the Germans, the desperate French government had reluctantly allowed Parisians to form a national guard to defend their surrounded city—reluctantly, because the government justifiably feared the independent spirit of Parisians. In February 1871 the French army, led by corrupt and inefficient officers, surrendered to German troops—who then planned what would have been to most Parisians a humiliating triumphant march down the Champs-Elysées. News of the proposed march strengthened the will of the national guard. They refused to surrender and

resolved to discourage the march with some two hundred cannon. But, having made peace with the Germans, the French government now regarded its own national guard as the enemy and set out to disarm them. Government troops sent to Paris to retrieve the cannon—and forestall a revolution—were driven off by the guards, who were joined by an enraged crowd that killed two generals.

The government retreated to Versailles, while many affluent residents fled to the country and the ailing emperor Napoleon III and his wife, Eugenie, sought sanctuary in England. The rebels then took over most of Paris, erecting barricades in the main streets in anticipation of a government counterattack. At the Hôtel de Ville on March 28, 1871, they proclaimed a revolutionary republican government known as the Paris Commune. During its brief regime, its supporters, Communards, canceled rents for the period of the fighting, created unemployment exchanges, allowed workers to reopen and run all factories deserted by their owners, and established day nurseries near the factories. Men who had pawned their tools to avoid starvation during the siege—when they had been reduced to eating rats—were allowed to retrieve their tools without charge. The rebels also instituted free education for all, including women.

Two months later government troops entered the city to take it back, and began a bloodbath unique in French history. In a week of savage fighting they butchered at least 30,000 Parisians and possibly as many as 100,000 for a loss of only 750 soldiers. They executed men, women, and children in groups of fifty or one hundred in the Jardin du Luxembourg, the Champ de Mars, and the Parc Monceau, and burned some six hundred Communards trapped in the Hôtel de Ville. They massacred rebels manning the street barricades and buried some alive in a ditch. The rebels also committed atrocities, shooting sixty-seven hostages, including the archbishop of Paris. They demolished entire streets of houses and torched the Louvre, the Palais de Justice, and the royal residence, the Tuileries Palace.

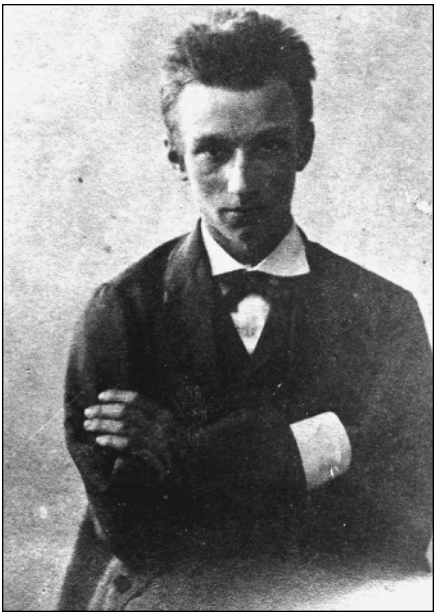
Although Pierre's father had not joined in the fighting, his heart was with the rebels. He converted the family apartment—they were now living on place de la Visitation—into an emergency hospital and sent his sons, Jacques, now sixteen, and Pierre, twelve, into the streets to bring back the most seriously wounded for him to treat. Despite the horrors the boys witnessed and the deadly risk they took by helping the rebels, for the next two years after the defeat of the Communards the Curies continued to live in a city under martial law and from which thousands were shipped to penal colonies, including Devil's Island. Some who had supported the revolt became informers to save their own lives. Archibald Forbes, a *London Daily*

News correspondent, saw such turncoats in action. "Yesterday," he reported, Parisians "had cried, 'Vive la Commune.' Today they rubbed their hands with livid currish joy to have it in their power to denounce a Communist and reveal his hiding place.* They have found him, a tall, pale hatless man with something not ignoble in his carriage. The crowd yells—'Shoot him; shoot him!' An arm goes in the air, and there is a stick in the fist. The stick falls on the head of the man in black. Men club their rifles, and bring them down on that head, or slash them in splinters in their lust for murder. A certain British impulse prompts me to run forward. But it is useless. They are firing into the flaccid carcass now. His brains spurt on my foot and splash into the gutter, whither the carrion is bodily chucked, presently to be trodden on and rolled on by the feet of multitudes and wheels of gun carriages."

Even if twelve-year-old Pierre Curie had never witnessed such killings in the streets, knowledge of them must have affected the ultrasensitive youngster. It explains in part why, in 1883, Dr. Curie moved with his family to Fontenay-aux-roses, and finally, about two kilometers away, to a small, old house on the rue des Sablons in Sceaux, a peaceful, leafy spot southeast of Paris, a paradise for bird lovers, with a range of ponds several miles long. But the move to the country did not improve Dr. Curie's finances. As an outspoken radical he could hardly expect to attract wealthy patients even had he wished to, which is doubtful. Instead, he held poorly paid jobs, first as a medical inspector for an organization protecting children and later as a school doctor. Fortunately, none of his family had expensive tastes. His sons' idea of a great vacation was to spend entire days at nearby Draveil on the Seine, where they walked for hours along the riverbank, cooling off with a dip in the river. At home they explored the country outside Paris. Sometimes Pierre went alone, becoming so enthralled by his surroundings that he lost all sense of time and arrived home late at night exhilarated but physically exhausted.

When Pierre was fourteen, his father realized that he was exceptional at math, especially spatial geometry, and hired Professor Albert Bazille to teach him advanced mathematics. Bazille inspired him to such intense effort that despite his early casual home schooling, he matriculated at the prestigious Sorbonne at sixteen. There, in just two years, he got a degree in physics. Then, at eighteen, because his financial help was needed at

* In those days the terms *Communist*, *Communard*, and *Socialist* were used indiscriminately and interchangeably.



Pierre Curie at nineteen, in 1878. The following year, a close female friend died—of a cause that remains a mystery—and he decided to be a lifelong bachelor and to devote his life to science.

home, instead of pursuing a doctorate, he began to work as a physics lab assistant at the Sorbonne. It didn't hurt that his brother, Jacques, was already employed as an assistant in the mineralogy department. As a pacifist, having seen the horrors of war, Pierre avoided military service, otherwise mandatory for eighteen-year-old Frenchmen, by agreeing to spend ten years working in public education—something he had already started to do as a lab assistant.

At this time he was deeply in love with a young woman he had known since childhood, but he was reticent, even guarded, about their relationship. In fact her identity has never been revealed. She may have become the mistress he obliquely referred to in his diary when he noted that the least distraction could seriously disturb him—such as when his mother kissed him. Though, strangely, he wrote that the kiss of a mistress was less "dangerous, because [it] can answer a purely physical need." Dangerous? Perhaps a less sensitive and introspective young scientist would have lightheartedly remarked that he welcomed his mistress's kisses more than his mother's. But to the easily distracted Pierre, apparently neither was welcome when he was engrossed in scientific speculation.

He explained this "weakness" in his diary, writing that to prevent his mind from flying away "on every wind that blows, yielding to the slightest breath it encounters," everything had to be motionless around him, or

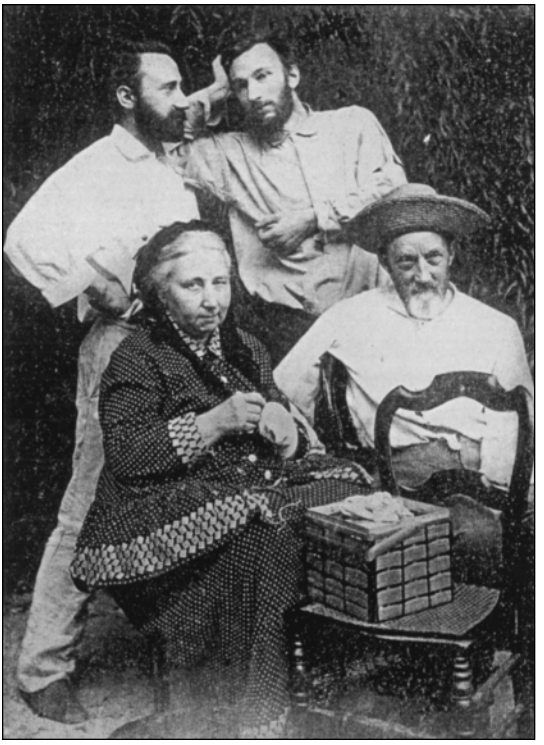
else, to overcome his surroundings, his mind had to be like "a humming top, the movement itself making me insensible to what is happening around me." He complained that his mother never seemed to understand this, adding, "Whenever, rotating slowly, I attempt to speed up [my mind], the merest nothing—a word, a story, a newspaper, a visit—stops me from becoming a gyroscope or top, and can postpone or forever delay the time when, with enough speed I might be able to concentrate despite my surroundings."

One welcome distraction was reading novels, and he was especially taken with Emile Zola's recent assertion in *The Experimental Novel* that novelists should adopt a scientific approach and become biologists of society. Zola had tried this by spending a few days in Lourdes on a fact-finding mission. He incorporated the facts and his impressions in a novel, *Lourdes*. In it he concluded that miracles, as such, did not exist, but that many people needed to believe in them—a rationalist view Pierre shared.

Yet it seemed something of a miracle that despite distractions and his despondency Pierre was able to marshal his "flying thoughts" to produce his first original work, in partnership with lab director Professor Paul Desains. They found a new, simple, and effective way to measure the wavelengths of heat waves, using a metallic wire grating and a thermoelectric element.

After that, Pierre's partnerships were invariably with his brother, Jacques, who shared his absorbing interest in nature and scientific research. They were so compatible, in fact, that they almost communicated telepathically. Or, as Pierre said, there was no need for them to speak to understand what the other was thinking. They also looked alike, dressed alike, sported beards, and wore similar rumpled clothes. They worked and played well together. The big difference between them was their relationship with their father. Jacques had such violent quarrels with him that it "scared their mother," said Pierre, who rarely raised his voice and would simply walk away from a potential quarrel.

The charming, intelligent parents imposed no religious strictures and encouraged their sons to think for themselves. Though nominally a Protestant, Dr. Eugène Curie did not follow any organized religion, believing, like his doctor father, that one should "do in this life that which Christianity expects only of the next life." He lived his beliefs, according to Marie Curie, being a loving husband and father, extremely unselfish, ready to help all in need, and completely uninterested in making money. Politically, the Curies subscribed to the republican ideal of "Liberté! Egalité! Fraternité!"



In his early twenties, Pierre Curie leans on the shoulder of his older brother, Jacques. His parents, Dr. Eugène and Sophie Claire, had realized that the ultrasensitive Pierre required an unorthodox education.

When Dr. Curie worked in the laboratory of the Museum of Natural History in Paris, he had imbued his sons with his own awestruck love of nature and the urge to bare its secrets. Although he wished to devote his life to full-time scientific research, he had to give it up in order to support his family as a physician. However, in his free time he investigated the possibility of using inoculations to prevent tuberculosis. His sons often headed for the fields and woods outside the city to bring back unusual plants, insects, and small animals for him to study and discuss with them. On these expeditions, Pierre showed a childlike reaction to almost everything he saw, appearing spellbound at the sight of a frog and staring with wonder at an elaborate cobweb.

These were therapeutic as well as delightful encounters, and he explained that when he was twenty he needed such trips to escape "from the thousand little worrying things that torment me in Paris."

Despite his scientific achievements, the unspecified torments in Paris overwhelmed him, so that at twenty-two he saw himself as a weak-willed failure lacking imagination and ambition. Another persistent torment was

his inability to stop feeling guilty for the death two years earlier of the woman he had loved. He never explained how she died and why he blamed himself, and it continued to haunt him. Even when writing to his future wife, Marie, some fifteen years after the tragedy, Pierre couldn't bear to give her the details: "When I was twenty I had a dreadful misfortune. I lost, in terrible circumstances, a childhood friend whom I loved. I haven't the courage to tell you all about it. I was very guilty. I had and will always have a great remorse about it. I went through days and nights with a fixed idea, and experienced a sort of delight in torturing myself. Then I vowed . . . to lead a priest's existence. I promised myself to be interested only in *things* after that, and never again to think of either myself or of mankind. Since the tragedy I have often asked if this renunciation of life was not simply a trick I used against myself to acquire the right to forget."

Since the tragedy, he had struggled to resist the wiles of seductive women and his own natural inclinations, and he began to define his attitude toward women in poetic, tortured, and somewhat misogynistic terms: "Women, much more than men, love life for life's sake," he wrote when twenty-two. "Women of genius are rare. Also, when we are impelled by some mystic love to enter into a life opposed to nature, when we devote all our thoughts to some task that removes us from those immediately about us, it is with women that we have to struggle. The mother wants the love of her child above all things, even if it should make an imbecile of him. The mistress also wishes to possess her lover, and would find it natural to sacrifice the rarest genius in the world for an hour of love. The struggle is almost always an unequal one because it is in the name of life and nature that they try to bring us back."

How did he maintain the struggle for some fifteen years? He confided to his diary a need to eat, drink, sleep, relax, and love, "that is to touch the sweetest things in this life, and yet not succumb." To do that "one must make the anti-natural thought to which one has devoted one's life remain dominant. . . . One must make of life a dream, and of that dream a reality." So he lost himself in work that intrigued him, investigating, with his brother, crystals, one of nature's many examples of symmetry. Pierre had marveled at the near-perfect symmetry of flowers and snowflakes, as well as the eyes, ears, and limbs of humans and animals—the tiger's "dreadful" symmetry that inspired one of William Blake's greatest poems. Although Pierre had also occasionally tried his hand at poetry, it was as a scientist that he chose to focus on the properties and symmetries of crystals.

He and his brother already knew that crystals heated in a fire attracted ash and wood to their surfaces like magnets. And they had heard of the discovery by Scottish physicist Lord Kelvin that when he heated certain crystals they generated electricity. This became known as pyroelectricity. The question was whether pyroelectricity applied to all crystals. Jacques's mentor, Charles Friedel, believed that it did and asked the Curie brothers to test his theory. They did, disproving it. The Curie brothers then went one step further, trying to prove that pressure on some crystals had the same effect as heat. Starting in 1879 and using remarkably simple equipment—a jeweler's saw, tinfoil, hardened rubber, and a vise—they put various crystals to the test. The results confirmed their theory: under pressure some crystals produced electricity.

In 1881 the brothers also experimentally confirmed Sorbonne professor Gabriel Lippman's theory that applying electricity to a crystal distorted its shape and made it vibrate, a discovery that would eventually have tremendous significance.

Marie Curie emphasized that the enterprise was more sophisticated than it sounds. "Their experiment," she wrote, "led the two young physicists to a great success: the discovery of the hitherto unknown phenomenon piezoelectricity [as it became known, from the Greek *piezine*, 'to press'], which consists of an electric polarization produced by the compression of the expansion of crystals in the direction of the axis of symmetry. This was by no means a chance discovery. It was the result of much reflection on the symmetry of crystalline matter which enabled the brothers to foresee the possibility of such polarization. The first part of the investigation was made in Friedel's laboratory [of mineralogy at the Sorbonne, where Jacques was Professor Friedel's assistant]. With experimental skill rare at their age, the young men succeeded in making a complete study of the new phenomenon, established the conditions of symmetry necessary to its production in crystals, and stated its remarkably simple quantitative laws, as well as its absolute magnitude for certain crystals. Several well-known scientists of other nations [Roentgen, Kundt, Voigt, Riecke] have made further investigations along this new road opened by Jacques and Pierre Curie."

To measure the minute amounts of electricity produced, Pierre, who was clever with his hands, invented and built an instrument he called an electrometer. Though there was no other immediate use for it, time and fate would change that most dramatically. The nine papers on piezoelectricity that he and his brother eventually published exhaustively covered

the subject. Their discovery is partly responsible for today's electronics industry and the ongoing search for additional uses of piezoelectricity in the growing field of solid-state physics. Piezoelectricity was used in World War I in a device called sonar, which created sound waves underwater able to detect enemy submarines, torpedoes, mines, and icebergs. These sound waves were reflected back as echoes by all objects in their path, and when the echoes were converted into electricity, an operator could determine the object's range, speed, and position. During World War II, the U.S. government used some fifty million quartz crystal elements for various purposes. And in 1954 a crystal was used to convert sunlight into electricity. Today, crystals are also used in microphones, electronic components, and quartz watches. A quartz crystal is stable even in extremes of temperature, so that a police officer using a two-way radio can move from a warm room to a freezing street and the crystals in the transmitter and receiver remain exactly on the correct frequency.

When Pierre was twenty-four, Jacques married and left to be head lecturer in mineralogy at the University of Montpellier hundreds of miles away in southern France, but they continued their joint research on crystals during their vacations. About the same time Pierre also quit the Sorbonne to take charge of the laboratory at the new School of Industrial Physics and Chemistry of the City of Paris. There, although able to conduct his own experiments, he also had to teach a class of thirty students. One of the most promising, Paul Langevin, recalled that his first impression of the new lab director was of a timid and awkward young man with a childlike laugh. But in time, though still shy, he became more assured and revealed "a flame of enthusiasm that inspired and encouraged his students." Then Langevin would return "with joy to [Curie's] laboratory, where it was good to work near him. He loved to stand in front of the blackboard and talk with us, to awaken interesting possibilities in us, and to speak of the work which was developing our taste for science." Once while he was teaching two students, either Pierre or his subject was so compelling that the trio lost all sense of time. And when they tried to leave, they found that the custodian had locked them in the second-floor room. To avoid spending the night on the floor, they all climbed through a window and down a drainpipe.

Pierre's opportunities to conduct his own experiments were extremely limited. In those days, he never had a proper laboratory entirely for himself and could use one only when students didn't need it. Otherwise he had to make do with a cramped corridor between a stairway and a classroom. Despite these restrictions, he formulated the principle of symmetry

on which much of modern physics relies, invented and built the ultrasensitive scientific weighing machine, the "Curie Scale," and began to investigate magnetism.

First he tried to see if he could make diamagnetic substances more magnetic by subjecting them to intense heat, but he couldn't. He then collected ferromagnetics (highly magnetic materials such as iron, cobalt, nickel, and some alloys) and put them to the same test. The result was a scientific breakthrough. As he increased the temperature they lost their magnetic characteristics until they became paramagnetic—only slightly magnetic. Today this temperature is known as the Curie point or Curie temperature. He also formulated a fundamental law, called Curie's law, stating that the magnetic power of a magnetic material varies in inverse proportion to the absolute temperature (zero).

For a decade he had lived up to his vow to devote himself entirely to his work. Not that he became a hermit. He went to art galleries and concerts, and continued to write poetry. He had several male friends, among them a cousin, Louis Depouilly; Albert Bazille, an engineer and son of his former math tutor; and a young doctor, Louis Vauthier. But Pierre avoided any serious relationship with a woman, which partly explains how at thirty-two he had achieved so much in his scientific work.

Yet for all the prestige he brought to the new school with his scientific discoveries, his teaching skill, and his devotion to work, Pierre Curie got about the same wage as a skilled factory hand. Then someone said that he could get a salary increase by applying to replace a professor about to resign. The problem was that a candidate, like a politician, had to canvass for support from others. And the retiring, modest man despised the convention and dreaded the prospect. As he explained in a letter rejecting the opportunity: "I am not accustomed to this form of activity, demoralizing in the highest degree. I think that nothing is more unhealthy to the spirit than to allow oneself to be occupied with things of this character and to listen to the petty gossip people come to report to you."

Though money generally didn't mean much to Pierre, there was a time when he was not reluctant to make a little extra, judging by his note on March 29, 1882, to Georges Gouy, a friend who bought several instruments Pierre had invented: "Thanks to you Lyon will be the city where our most important firm will make its biggest profits." In a fiercely competitive world, he not only refused to compete but put the kibosh on a proposal by the director of the school to recommend him for a government decoration in recognition of his contributions to science: "I pray you do not do so," he replied. "If you procure for me this honor, you will place

me under the necessity of refusing it, for I have firmly decided not to accept a decoration of any kind. I hope you will be good enough to avoid taking a step that will make me appear a little ridiculous in the eyes of many people. If your aim is to offer me a testimony of your interest, you have already done that, and in a very much more effective manner which touched me greatly, for you have made it possible for me to work without worry."

Although Pierre was hardly known outside a small scientific circle in France, an account of his work reached Lord Kelvin, the Scottish physicist of international renown. A major contributor to the laws of thermodynamics, Kelvin had published over six hundred papers on scientific subjects and patented seventy inventions. Both practical and gifted with a great imagination, Kelvin had directed the laying of the first successful transatlantic cable in 1866 and speculated that the germs of life on earth had come from another planet. He had also estimated the earth's age—the time it would take to cool from a molten state—as between 20 and 40 million years (the present-day estimate is 4.6 billion years).* A frequent visitor to Paris, Kelvin knew that the Curies' work competed with his. Having noted the effect of heat on crystals, Kelvin had expanded his research into their other properties. Now, reading of the Curie brothers' experiments, he realized that they had beaten him to it. To check their results he asked Pierre if he could send him an electrometer. Soon after Pierre sent one to him, as well as a piece of piezoelectric quartz, Kelvin responded on August 1893: "I thank you very much for having taken the trouble to obtain for me the apparatus by which I can so conveniently observe the magnificent experimental discovery of piezoelectric quartz made by you and your brother. I have written a note to the Philosophical Magazine, making it clear that your work preceded mine."

Two months later, Kelvin called on Pierre at his laboratory, where they talked shop for hours. This first of many visits led to their becoming friends, both having lost their innate shyness when discussing work. Had Kelvin claimed piezoelectricity as his discovery, Pierre would not have challenged him, according to Marie Curie, who characterized his attitude

* When Rutherford later estimated the earth's age to be billions of years (taking radioactivity into account), he had to present this result in a lecture. The story is that, discovering that old Lord Kelvin was in the audience, he searched for how to explain things without contradicting this most respected physicist. So he quoted Kelvin's calculations, adding, "Which naturally could not take into account an unknown source of energy." E-mail from Hélène Langevin-Joliot to the author, May 17, 2002.

as "that of a superior person who had reached the highest level of civilization," and his actions as those "of a really good man, full of understanding and forbearance, who was endowed with a strong sympathy for human nature." The work and the work alone was what mattered and not the individual. "What difference is there," he once said, "if I have not published the work as long as someone has?" He found competition so distasteful that he even opposed school examinations and ranking, as well as all distinctions and honors. Not that he ignored the talent of others. He encouraged and advised those he considered gifted and "was always disposed to aid anyone in a difficult situation and even to give of his time, which was the greatest sacrifice he could make." If Marie seems too partial, describing Pierre Curie as a flawless, almost saintly, man, no one has contradicted her—at least on the record.

His reputation for helping others explains why, in the spring of 1894, a Polish physics professor, Joseph Kowalski, invited him and Marie Sklodowska to a tea party in his rented apartment. Kowalski first met Marie when she was a governess in Poland, and now, while on his honeymoon in Paris and doing some lecturing, they met again. Marie, at the start of her scientific career, had told him of her futile search for a place to conduct experiments. And Kowalski believed that his friend Pierre Curie, a thirty-five-year-old bachelor, was just the man to help her.