theoretical contributions, her simplification of Kepler's work indicates that she was a competent mathematician and astronomer.

M. Cunitz, *Urania propitia sive tabulae astronomicae mire faciles* (Olsnae Silesiorum, 1650).

A23 129:424; **A32** 4:641; **A48** 1:504; **A49** **B16** **B35** **B51**.

Curie, Marie (Maria) Sklodowska

(1867–1934)
Polish physicist and chemist.
Born in Warsaw.
Parents: Bronislawa (Boguska) and Wladislaw Sklodowski.
Education: government secondary school, Warsaw (graduated 1883); "floating university," Warsaw (1884–1885); Faculty of Sciences, Sorbonne, Paris (1891–1896; licenciée ès physiques, *1893;* licenciée ès sciences mathématiques, *1894; Doctor of Physical Science, 1903).*
Governess in Poland (1885–1889); physics teacher, Ecole Normale Supérieure, Sèvres, France (1900–1906); assistant professor (1904–1906), professor (1906–1934), Faculty of Sciences, Sorbonne.
Married Pierre Curie.
Two daughters: Irène, Eve.
Died in Sancellemoz, Haute Savoie, France.
DSB.

During Maria Sklodowska's childhood, Poland was controlled by the tsar of Russia, and underground resistance to Russian rule was a constant factor in her early years. Her father, Wladislaw Sklodowski, had obtained a scientific education in Russia. When he returned to Warsaw to teach physics, he married the principal of a girls' boarding school. Although both husband and wife were members of the minor nobility, neither had any money, and they were forced to economize drastically. For the first eight years of the marriage, the family lived in a small apartment furnished by Mme. Sklodowska's school. During that period their five children, of whom Maria was the youngest, were born. After Maria's birth Sklodowski took a teaching post at a Warsaw high school for boys, which provided a larger apartment for his family; he obtained an additional job as a school underinspector. As a consequence of the increasing Russianization of Poland, when Maria was six her father lost his job as underinspector, and the family was obliged to move to a small house where they took in boarders.

Religion and success in school were emphasized in the household. Embittered by the deaths of her sister Zosia, of typhus (1876), and her mother, of tuberculosis (1878), Maria rejected the religious beliefs of her childhood. In 1883 she finished her secondary schooling with a gold medal—the third in the family. She was exhausted by the strain of academic achievement and, at her father's urging, took a year's vacation at her uncle's home in the country.

On returning to Warsaw, Maria Sklodowska allied herself with a coterie of young intellectuals—heirs of the revolutionaries of the 1840s—who met to discuss the ideas of the positivist philosopher Auguste Comte and other advocates of social reform. Girls made up a large part of the membership of this "floating university"—"mostly teenage girls with few responsibilities and time on their hands, young married women with little else to interest them, and the young daughters of successful bourgeois parents" (**G126** 24–25).

Electing to contribute toward her sister Bronia's education before saving money for her own, Sklodowska sought work as a governess. Her first job was a disaster: she and her employers developed a mutual dislike. Her second position promised to be more congenial, despite the dullness of provincial life and the necessity for self-repression. "If you could only see my exemplary conduct!" she wrote to a friend. "I go to church every Sunday and holiday, without ever pleading a headache or a cold to get out of it. I hardly ever speak of higher education for women. In a general way I observe, in my talk, the decorum suitable to my position" (G39 67). During her three-year tenure (1886–1889), however, she grew increasingly despondent and prone to illness, as the chance of extricating herself from the provinces seemed ever more hopelessly remote. A brief romance with the eldest son of her employers brought keener unhappiness: because of Sklodowska's inferior position as a governess, the family objected to their marriage; the attachment floundered and soon died. Nevertheless, throughout her governess years she forced herself to read and study, finding physics and mathematics especially interesting and challenging.

An escape became feasible when Sklodowska's father accepted the directorship of a reformatory and was able to send money himself to Bronia, now a medical student in Paris. Sklodowska returned to Warsaw, where she worked as a governess and tutor for two more years. During this period Bronia married and invited Maria to come to Paris and share her home while going to school. After hesitating for over a year, Maria accepted. In 1891 she became a student at the Faculty of Sciences of the Sorbonne.

Even though she had studied hard on her own, Sklodowska discovered tremendous gaps in her education in physics and mathematics, which she worked feverishly to repair. The romantic story of her spartan existence in Paris is well known. She left her sister and brother-in-law's apartment for a more convenient, but monastically simple, lodging in the Latin Quarter, where she endured severe cold and hunger, feelingly described in her daughter Eve's account of her life. Biographer Robert Reid, on the other hand, asserts that "a myth has grown up about the poverty of her student days. She *was* poor, but so were most students. Her allowance from Poland was small and had to be divided between tuition fees and the price of life in the garret. When the cost of fuel was high there was little left for food; the main protein cooked over her spirit stove was usually egg. In student history the omelet can probably claim to have sustained more educations than any other stimulant" (G126 48). Yet it is apparent that Sklodowska carried self-denial past the ordinary levels. At one point she almost starved herself until rescued by Bronia's husband. After he and Bronia fed and nursed her back to health, she "began again to live on air" (G39 109–110).

In 1893 Sklodowska received her degree in physics from the Sorbonne. She had come to realize the importance of mathematics to a deeper understanding of physics and therefore, after vacationing in Warsaw, returned to Paris to work on a degree in mathematics. This time the financial situation was easier, for in Warsaw she had been awarded the Alexandrovitch Scholarship for outstanding Polish students who wished to study abroad. The scholarship money supported her for over a year.

During her second year in Paris (1894) Sklodowska met Pierre Curie (1859–1906), who was then laboratory chief at the School of Industrial Physics and Chemistry. Curie was engaged in research in the physics of crystals. Together with his brother, Jacques, he had in 1877 discovered the phenomenon of piezoelectricity—the generation of electricity by certain crystals when deformed by mechanical stress—which was to have important applications in many fields, especially that of electroacoustics. His work during the 1880s had dealt with principles of symmetry, as they applied both to crystallography and to physics as a whole; in 1891 he had completed a doctoral dissertation on the magnetic properties of various substances at different temperatures. Curie had scorned to seek his own advancement and had not progressed up the academic ladder. He and Sklodowska, both shy and introverted people, shared the conviction that the scientist must work from entirely disinterested motives.

Marie Sklodowska received her mathematics degree in 1894 and in the following year married Pierre Curie. They honeymooned by bicycling through the Ile de France—a vacation pattern that they continued throughout their marriage. Returning to Paris, the couple settled into a routine of work as a team at Pierre's laboratory. In 1897 Marie published her first paper, on the magnetism of tempered steel. An interruption occurred in the form of Marie's pregnancy; their daughter Irène was born in September 1897.

The possibility of giving up her research did not occur to Mme. Curie. In addition to recording quantifiable data about little Irène—"April 15, Irène is showing her seventh tooth down on the left" (G39 163; G126 84)—she began to search for a suitable subject for a doctoral dissertation. Intrigued by Wilhelm Roentgen's discovery of X rays and by Henri Becquerel's findings on the radiation-emitting properties of uranium salts, both announced in 1896, she and Pierre decided that an investigation into the nature of radioactivity (a term coined by Mme. Curie and first used in a joint paper by the Curies in 1898) might serve the purpose.

Postulating that the capacity to emit radiation was an atomic property, Mme. Curie proposed to search for additional radioactive substances. Since two uranium ores that she tested, pitchblende and chalcolite, exhibited a much stronger degree of radioactivity than would have been forecast from the quantity of uranium that they contained, she hypothesized the presence of a highly radioactive element.

Pierre Curie, who had been following the results closely, tabled his own projects on crystals to work with Marie. In their partnership Marie was the chemist, separating and purifying the fractions of pitchblende, and Pierre was the physicist, determining the physical properties of the results. Although they had not yet succeeded in isolating them, the Curies were certain enough of their existence to announce the discovery of two new elements—polonium (named after Mme. Curie's native land) and the more active radium—in July and December 1898.

The problem of isolating their theoretical substances was a financial as well as a technical one. Crude pitchblende was expensive. Recognizing that the far cheaper residue—the portion remaining after extraction of the uranium—would suit their needs, the Curies used their savings to buy the material from the St. Joachimsthal mines in Bohemia and to have it transported to Paris. A shed with an earth floor, formerly used as a medical-school dissecting room, was the location of what proved to be four years' work. This structure "surpassed the most pessimistic expectations of discomfort. In summer, because of its skylights, it was as stifling as a hothouse. In winter one did not know whether to wish for rain or frost; if it rained, the water fell drop by drop, with a soft, nerve-racking noise, on the ground or on the worktables, in places which the physicists had to mark in order to avoid putting apparatus there. If it froze, one froze" (G39 169). The physicist Georges Urbain (1872–1938) reported after a visit that he "saw Madame Curie work like a man at the difficult treatments of great quantities of pitchblende." She moved the heavy containers, transferred the contents from one vat to another, and, "using an iron bar almost as big as herself," spent "the whole of a working day stirring the heating and fuming liquids" (G126 96).

To Pierre Curie it seemed superfluous to engage in the enormous physical struggle to demonstrate what they already knew. He was "exasperated to see the paltry results to which Marie's exhausting effort had led" (G39 174). Nonetheless, in 1902 Marie succeeded in isolating a decigram of radium chloride and making a first determination of the atomic weight of radium, 225.93.

Despite Pierre Curie's impressive research achievements, he was continually passed over for promotion. In order to help support the family, Marie taught physics at a girls' high school in Sèvres from 1900 to 1906, using what time she had left for research and the preparation of her thesis. The health of both Curies was deteriorating. Though they knew the cause of the burns on their hands, they refused to connect their general debilitation with exposure to radiation. Not even in Pierre's last paper, written in 1904, on the experimental effects of radioactive emanations on mice and guinea pigs—where he and two medical colleagues reported that a post-mortem examination of the affected animals showed intense pulmonary congestion and modifications of the leucocytes—did he appear to apply these results to his own and Marie's symptoms.

Marie Curie defended her doctoral thesis, a comprehensive review of her own and others' research in radioactivity, at the Sorbonne on June 25, 1903. In the crowded examination hall, curiosity seekers as well as family, friends, and colleagues were present. After the examination she was awarded the degree of Doctor of Physical Science in the University of Paris, with the added accolade of *très honorable*.

The year 1903 was one of contrasts for the Curies. Pierre, accompanied by Marie, made a trip to London to present a lecture at the Royal Institution. It was well received and his party tricks with radium especially appreciated. During one demonstration he spilled a minuscule quantity of radium; fifty years later the level of radioactivity in the building was sufficient to require decontamination. In the same year Marie lost a child, born prematurely after one of their bicycle rides. During this pregnancy she had been exposed to extremely high doses of radiation.

In December 1903 the Curies and Henri Becquerel were jointly awarded the Nobel Prize for physics—an event that destroyed forever their voluntary isolation. Becquerel went to Stockholm to receive his award, but the Curies, who were both unwell, pleaded uninterruptible teaching schedules as the reason for their absence. It was not until June 1905 that the Curies were able to travel to Sweden, where Pierre gave the lecture required of Nobel recipients.

The year 1904 was less of a burden than its predecessor. A healthy daughter, Eve, was born; Pierre was named occupant of a newly created chair of physics at the Sorbonne. And in the following year Pierre was elected to the Academy of Sciences. The Curies were continually confronted, however, with the uncomfortable fact that radium experiments had entered the realm of public science. The spectacular nature of radioactivity and its potentially rewarding applications—including the treatment of cancer, which the Curies foresaw as early as 1903—removed some of the Curies' research from the ivory tower. Scrupulous in their belief that the results of scientific research should be in the public domain and equally convinced that investigators should not profit materially from the results of their investigations, the Curies did not take financial advantage of the lucrative radium industry that was growing up around them.

Although by 1906 Pierre's health was wretched, it was not sickness that ended the partnership. On a rainy day in April, while crossing a busy street in his usual state of preoccupation, Pierre Curie stepped into the path of a horse-drawn wagon and was instantly killed. According to the Curies' daughter Eve, "from the moment when those three words, 'Pierre is dead,' reached [Mme. Curie's] consciousness, a cape of solitude and secrecy fell upon her shoulders forever. Mme. Curie, on that day in April, became not only a widow, but at the same time a pitiful and incurably lonely woman" (G39 247).

Within a month of Pierre's death, Marie Curie had returned to work at her laboratory and had been appointed to fill Pierre's vacant chair at the Sorbonne, with the status of assistant professor. She was the first woman in France to receive professorial rank and within two years became titular professor. Her immediate financial problems were solved, and she had her own facilities for research. She now undertook the defense of her results against the onslaughts of the aging Lord Kelvin (1824–1907), who was never able to accept the implications of the new research on radioactivity. Finding intolerable the idea that atoms were capable of disintegration, he attacked both the Curies' findings and those of Ernest Rutherford (1871–1937) and Frederick Soddy (1877–1956), who during the first years of the twentieth century were developing a theory of the radioactive transformation of atoms. When Kelvin questioned the elemental status of radium and polonium, Mme. Curie, who had herself expressed some doubts in the case of polonium, began the long purification process again. Although when she had finished her work—in 1907, after Kelvin's death—her hypothesis had again been corroborated, the labor had taken a further toll on her health.

During Pierre's lifetime Marie Curie had been idolized by the public and honored by her colleagues as well. After his death, however, her sometimes icy and haughty manner offended some of her contemporaries. Her originality was questioned by some—notably the physicists Bertram Borden Boltwood (1870–1927) and Ernest Rutherford, who attributed her success more to hard work and tenacity than to any innate creativeness. The lack of colleague support was demonstrated during Mme. Curie's attempt to be elected to the Academy of Science in 1911. As soon as she announced her decision to become a candidate, the newspapers seized upon an interesting publicity opportunity. Some articles were effusive in their praise; others claimed that she was seeking credit for work done by her husband. Accusations of unsavory dealings proceeded after she lost the election—by one vote on the first ballot and by two votes on the second. Although Curie pretended indifference, she was hurt badly. Further, the press had developed a taste for probing the secrets of her life.

In the autumn of 1911 reporters uncovered evidence that apparently transformed Marie Curie from a stoic grieving widow—a model of lifelong fidelity and symbol of the ideal partnership between man and woman—to a vicious homewrecker and flaunter of accepted sexual mores. On November 4 the Parisian newspaper *Le Journal* published an article under the headline "A Story of Love: Mme. Curie and Professor Langevin," which purported to prove, on the basis of stolen letters, an adulterous affair between Marie Curie and the eminent physicist Paul Langevin, whom she had known for many years. An international scandal followed.

Four days after the appearance of the article, Curie received a telegram informing her that she had been awarded the Nobel Prize for chemistry. The unprecedented award of a second Nobel Prize to the same person was hardly noticed in the newspapers, which had more interesting material to print. The strain of curiosity seekers invading Curie's privacy and that of her children, the publication of large incriminating extracts from the letters, and three resultant duels may have caused a chronic kidney infection to become worse, nearly bringing her death. During the period of recuperation from the necessary kidney surgery, she lived in seclusion under the name "Madame Sklodowska."

Curie's reentry into society was gradual. At the request of the English scientist Hertha Ayrton (q.v.), whom she had met in 1903 and corresponded with ever since, she signed an international petition requesting the release of three women suffrage leaders who were on a hunger strike in a British jail. For several months in 1912 she stayed with Ayrton in England, incognito, finishing her recuperation. The last entry Curie had made in her notebook on radium standards had been dated October 7, 1911; she began to make notes again on December 3, 1912.

The Langevin scandal having died away, Curie devoted much of her time to the development of a new research institution to be dedicated entirely to radioactivity. The Institute of Radium was, according to an agreement reached in 1912, to be built jointly by the Pasteur Institute and the Sorbonne and would consist of two parts: one, directed by Marie Curie, was to be devoted to physical and chemical research and to be supported by the university from a government grant; the second, directed by Claude Regaud, was to be used for medical and biological research and to be supported by the Pasteur Institute. Although the building was completed in July 1914, World War I intervened to prevent its occupation by scientists.

Immediately recognizing the need for mobile radiological equipment on the battlefield, Curie approached French government officials with a plan of action. Appointed director of the Red Cross Radiology Service, she solicited money and equipment from individuals and corporations for the establishment of a fleet of X-ray cars. Together with her daughter Irène, she visited the battlefields herself and whenever possible established fixed radiological stations. She turned the unused Institute of Radium into a school for training young women in X-ray technique and, again with Irène as assistant, conducted the classes herself.

Although the end of the war signaled Curie's opportunity to resume research, the materials with which to do so were hard to come by in depleted postwar France. One of the greatest deficiencies was the lack of radium itself. More amenable to public compromise in order to attain her ends than had been Pierre, Marie agreed in 1920 to a fundraising proposal by an American journalist, the somewhat brash, but great-hearted, Marie Meloney. Meloney would organize a subscription campaign among American women to provide the Institute with the needed radium, and in return Curie would come to America, accompanied by Irène and Eve, to receive it. The campaign succeeded; in May 1921 President Harding presented a gram of radium to her (actually an imitation, since the genuine material was locked up). The planned tour of the United States, reception of numerous honorary degrees, and speeches so tired Curie that the visit was shortened.

Not until the 1920s did the lurking question of the health hazards of radium come to the fore. Workers in Curie's laboratory experienced fatigue and aching limbs. Curie, who had long had sores on the tips of her fingers, was losing her eyesight to cataracts. As the radium industry boomed, cases of sickness and even death among exposed persons began to be reported; pernicious anemia and leukemia were diagnosed in radiation laboratory personnel. Curie was confronted with the paradox that radium could both cure and possibly cause cancer. In spite of her own deteriorating physical condition, she was hesitant to admit radium's culpability. Surgery removed her cataracts and she was able to see again. Since her own constitution was remarkably resilient, she remained unconvinced that radium could kill.

During her last years Marie Curie sought the companionship of her daughers—Irène, her scientific colleague, who in 1926 married the physicist and chemist Frédéric Joliot, and Eve, the nonscientist, who took care of her mother's physical and emotional needs. Often accompanied by one of them, she traveled throughout Europe and beyond, giving lectures, attending conferences, and raising money for research. One of her projects was a campaign, sparked by her sister Bronia, to modernize Polish medicine by establishing a radium research institute in Warsaw. Although the physical structure had long been completed, there was still no money to equip the Marie Sklodowska-Curie Institute with radium when in 1928 Marie Meloney agreed to mastermind a second American visit by Mme. Curie. The trip was both profitable and timely: Curie received the cash only days before Black Thursday.

Curie continued lecturing at the Sorbonne and supervising the work at her laboratory, although she increasingly yielded authority in the latter to Irène and Frédéric Joliot-Curie. She became active in the League of Nations' International Committee on Intellectual Co-operation and maintained friendships and correspondence with such leading European intellectuals as Albert Einstein.

In 1932 Mme. Curie broke her right wrist in a fall in the laboratory. The injury, which did not heal properly, was the beginning of a long decline. It was happily on a day when she was present at the laboratory that Irène and Frédéric Joliot-Curie carried out the momentous experiment in which, by bombarding the nucleus of an aluminum atom with alpha particles, they created a radioactive isotope, thus achieving artificial radioactivity. This was in January 1934. In May Curie's doctors misdiagnosed her condition as tuberculosis and prescribed a trip to a sanatorium in the mountains. On the way, she developed a high fever. A blood count led to a new diagnosis, a severe form of pernicious anemia. On July 4, 1934, she died.

A review of Marie Curie's scientific achievements must, of necessity, address the relationship of her creativity to Pierre's. Did he supply the original ideas and Marie implement them? Was it significant that the original theoretical breakthroughs occurred within his lifetime? Here the assessments of Rutherford and Boltwood must be taken into account. Referring to her *Treatise on Radioactivity* (1910), Rutherford reported in a letter to Boltwood that "in reading her book I could almost think I was reading my own with the extra work of the last few years thrown in to fill up.... Altogether I feel that the poor woman has laboured tremendously, and her volumes will be very useful for a year or two to save the researcher from hunting up his own literature; a saving which I think is not altogether advantageous" (G126 168).

When Mme. Curie received her second Nobel Prize, Boltwood was outraged because the theoretical work of Theodore Richards (1868–1928) on atomic weights had not been honored; instead, Marie Curie had received the reward for what Boltwood considered to be stubborn perseverance rather than theoretical brilliance. He wrote to Rutherford that "Mme. Curie is just what I have always thought she was, a plain darn fool, and you will find it out for certain before long" (G126 213). The chemist George Jaffe, who visited the laboratory, assumed that it was Pierre "who introduced the ingenuity into the scientific concepts ... and the powerful temperament and persistence of Marie that maintained their momentum" (G126 91). Mme. Curie was aware that critics proclaimed the originality in their work as her husband's. The fact that in their papers it is always "we" whose efforts are described makes it difficult to extricate individual contributions.

In her 1911 Nobel speech, however, Mme. Curie made clear by her use of pronouns what she had contributed. The prize in chemistry was given to Marie Curie "in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element" (G111 197). In presenting the historical background to the work, she clarified her priority: "Some 15 years ago the radiation of uranium was discovered by Henri Becquerel, and two years later the study of this phenomenon was extended to other substances, first by me, and then by Pierre Curie and myself" (G111 202).

One of the most significant theoretical assumptions surrounding radioactivity was the postulate that it was an atomic property. In Marie Curie's initial study of the "power of ionization" of uranium rays—that is, their ability to render the air a conductor—she used the method of measurement invented by Jacques and Pierre Curie, an "ionization chamber, a Curie electrometer, and a piezoelectric quartz" (G39 155; M. Curie, *Radioactive Substances*, 7–11). But it was the conclusion from the measurements that constituted the scientific originality. It is unclear from the original publication whether Marie or Pierre had conceived the idea, for to them at that time it was obviously irrelevant. They concluded that the intensity of radiation is proportional to the quantity of material and that the radiation was not affected either by the chemical state of combination of the uranium or by external factors such as light or temperature. This led to the important theoretical breakthrough that radiation was an atomic property. In 1911 Marie Curie's Nobel Prize lecture made it clear that this idea was hers. "The history of the discovery and the isolation of this substance," she noted, "has furnished proof of my hypothesis that *radioactivity is an atomic property of matter and can provide a means of seeking new elements*" (G111 202–203). In her thesis (1903) she had not used the first person to describe the creation of this hypothesis, writing that "the radio-activity of thorium and uranium compounds appears as an *atomic property*" (*Radioactive Substances*, 13).

In Pierre Curie's Nobel lecture of 1905, he did not designate individual roles, writing that "radioactivity, therefore, presented itself as an atomic property of uranium and thorium, a substance being all the more radioactive as it was richer in uranium or thorium" (G112 73–74). From this lecture it is also unclear which one of the pair invented the term "radioactive." "We have called such substances *radioactive*," he observed (G112 73). Marie, however, used the first person singular in her 1911 lecture, noting that "all the elements emitting such radiation I have termed *radioactive*, and the new property of matter revealed in this emission thus received the name *radioactivity*" (G111 202). In her thesis she also noted her own part, writing that "I have called *radio-active* those substances which generate emissions of this nature" (*Radioactive Substances*, 6).

The hypothesis of the atomic nature of radioactivity motivated the long search that resulted in the isolation of polonium and radium. And the imaginative creation of a hypothesis distinguishes the scientist from the ordinary investigator. To be sure, Marie Curie's scientific genius had a second characteristic, perseverance. The labor necessary to substantiate her hypothesis was excruciatingly tedious and demanding. Whereas to Pierre the inexorable logic of the hypothesis was sufficient proof of its truth, for Marie it was necessary to demonstrate the substances' existence physically as well as hypothetically. Her tenacity in the physical labor of attaining the pure material has contributed to the charge that her part in the Curie team was the less creative one. The evidence indicates, however, that in the discovery of radium Marie Curie contributed both the necessary hypothesis and the perseverance to demonstrate it physically.

In her later work the charge that Marie Curie was more involved in the minutiae of laboratory analyses than in creating new theories has more substance. Her insistence on isolating pure radium and pure polonium is a case in point. In her first effort to isolate radium, she had ended up with very pure radium chloride but not elemental radium. Lord Kelvin's suggestion (1906) that radium was not an element but a molecular compound of lead with a number of helium atoms had put in jeopardy her own work as well as Rutherford and Soddy's theory of radioactive disintegration. Therefore, Curie began another series of laborious purifications, this time to be sure that she ended up with elemental radium; at the same time she determined to settle the question of polonium's elemental status as well. Even though this eventually successful process undoubtedly required skill and infinite patience, it did not involve additional suppositions. Similarly, the establishment of a radium standard in 1911, though an important achievement, was not predicated on additional theoretical assumptions.

Marie Curie's most scientifically creative years were indeed those during which she and Pierre shared ideas. Nonetheless, the basic hypotheses—those that guided the future course of investigation into the nature of radioactivity—were hers. Most of her later efforts were spent in elaborating on, refining, and expanding these early ideas.

M. Curie, *Pierre Curie*, translated by Charlotte and Vernon Kellogg, with introduction by Mrs. William Brown Meloney and autobiographical notes by Marie Curie (New York: Macmillan, 1923); *Radioactive Substances* (New York: Philosophical Society, 1961); *Recherches sur les substances radioactives*, 2d ed., rev. and corr. (Paris: Gauthier-Villars, 1904).

A9 47:22–24; A23 129:576–577; A24 34:818; A41 3:497–503; G39 G111 G112 G126.

Cushman, Florence

See Appendix

Ogilvie, Marilyn Bailey, *Women in Science,* MIT Press, 1988 (pp. 64-72)