Chapter 3
Gender, Science, and the City

1 In 1886, when the physicist Ernest Mach asked, "How is humanity to progress safely if not even half of it is walking on an enlightened path?" women had not been accepted yet to the University of Vienna. As he argued in his popular scientific lectures, "The level of education and choice of profession for women should in no way be restricted."[1] In the mid-1890s, and while the acceptance of women at the University of Vienna was still under discussion, Mach, with his colleagues and the directors of the first and second Physics Institutes, Victor von Lang and Franz Exner, founded a committee for the support of women's admission to university studies.[2] Surprisingly, leading figures in Vienna's physics community, such as Exner, Mach, and Lang, all members of the intelligentsia and bourgeoisie, contributed immensely to creating a friendly environment for the young women of their social strata to create a space for themselves within the field of physics.

2 Cradled in fin de siècle Vienna, such physicists as the young Stefan Meyer inherited their cultural meanings about sexual difference and a collegial ethos of working in physics from Vienna's cultural and scientific milieu. At the turn of the century, Vienna was an extraordinary cultural setting where psychoanalysts, architects, artists, writers, musicians, politicians, philosophers, and scientists transformed their fields of knowledge, established new ones, and defined new ways of being. The city's intelligentsia produced distinct schools of thought in architecture, music, painting, philosophy, and psychology. Figures such as architects Adolf Loos and Otto Wagner, social critic Karl Kraus, composers Gustav Mahler and Arnold Schönberg, painters Gustav Klimt and Egon Schiele, philosopher and author Robert Musil, and the founder of psychoanalysis, Sigmund Freud, are only a few of those who marked the turn of the century, and they are among those who contributed to the myth of Vienna as one of the most creative milieus in Europe.

3 Starting in the early 1960s, the work of historian Carl Schorske became the dominant paradigm in understanding 1900 Vienna as the birthplace of a major part of modern culture and thought. The defeat of liberalism and the political crisis of the 1890s provided the context for elucidating the cultural success of the city. As Schorske argues, "the writers of the nineties were children of a threatened liberal culture."[3] Establishing their power in a struggle against aristocracy, liberals had their heyday between 1860 and 1880. By 1900, new political forces such as

feminists, Social Democrats, and the anti-Semitic Christian Socials had gained enormous political influence. Although defeated by the new political forces, the liberals had already provided the space where the new social and political powers could evolve. The feverish urban reconstruction of the late 1880s and 1890s had created potential spaces of cultural and scientific activity in the margins of Ringstrasse. Viennese modernism was produced through the cultural elite's reaction to this "failure of liberalism."

4 As Steven Beller explains, the Schorskean paradigm turned Vienna into a fashionable topic of research, and until the 1980s Schorske's work was accepted as the canonical view of fin de siècle Vienna. Posing the question of the Viennese Jewish contribution to the modern culture, historians such as George Steiner and Ivar Oxaal seemed to threaten the Schorskean model by the mid-1980s. The acknowledgment by Schorske of the Jewish dimension to the production of Viennese culture was not enough. The new argument fully acknowledged the Jewish tradition and experience in Vienna's modern culture. More recent studies have further undermined the theses of the failure of Austrian liberalism, showing that the liberal bourgeoisie retained a great influence in the Austrian state through their economic and political power.[4] What has emerged from challenging Schorske's model is a more complex picture of the relationship between politics and culture in fin de siècle Vienna.

5 Part of the intellectual and cultural cartography of the era has been the strong women's movement that developed at the turn of the century. Overshadowed by the Schorskean paradigm, women's history in 1900 Vienna has been mostly neglected. According to Harriet Anderson's *Utopian Feminism*, the most frequently cited work on fin de siècle feminism, progressive Viennese women did not limit their interests to practical goals but aimed to a new social order and deeper sexual and moral reforms. Yet, they did campaign for more vocational opportunities such as the right to vote and a state-supported secondary and higher education.[5] They certainly succeeded in the latter cause. Before the end of the century, women were finally accepted to the University of Vienna thanks to the persistent petitions and campaigns by feminists, supported by the Social Democrats, and despite the counteractions of the conservative Christian Socialists.

6 However, the city of Vienna was not just the stage, a mere social and political setting for women's emancipation and high cultural reforms. It was also a sociospatial setting where the practices and characteristics of the urban environment molded meanings of sexual difference and progressive politics.[6] If

the oldest historical parts of the inner city were identified with the nobility of the aristocrats, the area around the new university, the Mediziner-Viertel, nurtured the reformists. Science and culture, politics and philosophy encountered one another in a small quarter, all within a 15-minute walk. Instead of speaking about women's segregation from this extraordinary milieu, I choose to focus on the ways they were integrated into the culture of Viennese science, taking advantage of the locally specific articulations of class and gender in a space such as the Mediziner-Viertel.

Designing the University of Vienna

7 After the failure of the liberal revolution in 1848, in which the university faculty and students played an essential role, the imperial army of the Habsburg Empire occupied the old university in the inner city. As a result, institutes were scattered in the outer districts presenting the university with a disciplinary diaspora. The chemistry and physics institutes were moved into the third district of the city. The medical faculty was housed in the Josephinum at Wäringerstrasse in the ninth district and later moved to the old artillery industry in the corner of Schwarzspanierstrasse and Wäringerstrasse, behind the Votivkirche. Only the faculty of theology had moved to Stadkonvikt, in Dr. Ignaz-Seipel Platz next to the Academy of Sciences in the inner city, where lectures on philosophy and law were also held.[7] Clearly, the emperor aimed to dispel the intellectuals, enfeebling their political influence. At the same time, expelling most of them from the inner city was a strategy for ensuring the aristocrats' safety from any revolutionary threat.

8 During the 1850s, Vienna experienced an immense economic growth. Economic enterprises doubled, as did the population of Vienna. The textile industry became the main financial source for the empire and attracted a considerable number of workers from the countryside. Consequently, the Emperor Franz Joseph I decided in 1857 to extend the inner city of Vienna, decreeing that the military area around it be converted to civilian use. After assuming power in 1860, the liberals meanwhile saw Vienna as the center of their intellectual life and as a symbol of their ideological commitments. One of their first concerns was the architectural transformation of the city and soon the core of Vienna's urban reconstruction was the Ringstrasse.

9 A 60-foot-wide tree-lined boulevard in the shape of a ring replaced the walls around the inner city of Vienna and offered to the newly emerging bourgeoisie the space to fulfill its expectations. For example, textile manufacturers belonged to the

group with the second highest ration of home owners in the Ringstrasse area after the nobility. As Schorske argues, "the art of building, used in the old city to express aristocratic grandeur and ecclesiastical pomp, now became the communal property of the citizenry, expressing the various aspects of bourgeois cultural ideal in a series of so-called Prachtbauten (buildings of splendor)."[8]

10 The Opernhaus (1869), the Parliament (1883/4), the Rathaus (1883), and other monumental buildings along the Ring indicated their purpose by their impressive architecture: parliamentary government, municipal autonomy, dramatic art, and liberal ideas. Since Vienna's university, however, signified the revolutionary and oppositional forces that played a central role in the revolution of 1848, attempts to include its new building on the Ringstrasse generated long-standing conflicts within the government and delayed its construction.

11 Already in 1849, Count Leo Thun-Hohenstein, the minister of education and religion, took a special interest in restoring the scientific and administrative autonomy of the university. The reform program included the architectural grouping of all university faculties and administrative offices. Thun's plan was to group several buildings around the main university site and create a *civitas universitatis* in Gothic style. In 1853, along the same lines, two of the most important architects of the time, Eduard van der Nüll and August von Sicardsburg, proposed a neo-Gothic design for the university. It was a complex of four buildings arranged around two inner courtyards. The first and main building hosted the philosophical faculty and the law faculty, lecture halls, and administration offices. The library was located in a separate building as were the chemistry and the physics institutes. A sacred edifice functioned as the university's church.[9] They proposed to locate it behind the Votivkirche, a Gothic basilica designed by Heinrich von Ferstel. Nonetheless, the plans met with the immediate objection of Ferstel, who disliked the proximity of two Gothic monumental buildings. For the next 15 years, given the obstructionism of the city, the lack of money, and Ferstel's opposition, Thun and his collaborators worked in vain to create the new university. It was only thanks to the liberals' initiatives that the university finally took its place on Ringstrasse in front of the Votivkirche.[10]

12 In 1868, the mayor of Vienna, Kajetan Felder, assigned Ferstel to provide new site plans for the university. Changing the architect in charge meant also modifying Thun's original ideal of the medieval *civitas universitatis.* Increasing needs related to Vienna's economic growth and industry as well as to scientific developments required different structures and architectural forms. Besides adding research

laboratories, seminar rooms, and clinics to the traditional lecture halls, Ferstel tried to create a Universitätsviertel, a quarter of science buildings open to the city but sufficiently close together to facilitate the work of the faculty and students. Intentionally, he planned to accommodate Vienna's Allgemeines Krankenhaus (general hospital) in the quarter and locate all different buildings within a ten-minute walk. As his model, Ferstel chose the Italian universities and their Renaissance designs. In 1871, he traveled to Italy, visiting the "cradle of modern humanistic learning," the traditional universities of Bologna, Genoa, Padua, and Rome.[11] Eventually, when the university opened on October 11, 1884, the modern humanistic ideals of education that both the liberals and its architect endorsed were clearly indicated in its Renaissance façade.[12]

From the Universitätsviertel to the Mediziner-Viertel

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The Mediziner-Viertel, a triangular piece of land defined by Währingerstrasse, Alserstrasse, and Spitalgasse acquired its existence in fin de siècle Vienna not only by bringing several scientific institutes together in that specific location but by transforming the area into a vital cultural and epistemic centre in the city. Originally, it was dominated by the *Zinhausen*, several-story buildings designed as apartments and offered as a solution to the significant housing shortage in the city. Built to house the working class, they usually contained 16 units and were absolutely inferior to the *Adelspalais*, the aristocratic palaces they were trying to mimic architecturally.[13] As Emil Kläger and Max Winter, the Viennese journalists of *Arbeiterzeitung,* described the housing on the margins of Ringstrasse, where apartments averaged around 43 square meters, "There are four beds, in which some seven adults and one child sleep . . . . The apartment is damp to a height of 1.1 meters. Rent is 20.40 crowns per month. There is no water in the house and the roof is badly in need of repair."[14] By the turn of the century, the face of the city's ninth district was changed radically by the number of scientific institutes that were founded and the new culture they established.

14

As early as 1783 to 1784, impressed by the Central Hospital in Paris, the Emperor Joseph II commissioned his architect Isidor Canevale and the court physician Joseph Quarin to design Vienna's Allgemeines Krankenhaus. The idea was to close the smaller hospitals that were dispersed around the city and group all medical facilities in one extensive complex. In the final plan and in addition to the main hospital building, there was a maternity wing, an asylum known as the *Narrenturm*, an infirmary, and a foundling hospital, all in separate edifices around

several courtyards. Considered to be the last Baroque building in Vienna, the Josephinum, located at 25 Währingerstrasse in front of the Narrenturm, housed the surgical and medical faculty and part of the hospital. It was originally designed to accommodate army surgeons who did not have medical degrees and were organized in craftsmen's guilds. The building hosted a spectacular collection of 1,192 wax models of normal human anatomy, designed and prepared at the famous La Specola, the Royal Museum of Physics and Natural History in Florence. The models were used for the teaching of the Viennese surgeons and constituted the subject of an ongoing controversy between medical professionals during the late eighteenth and early nineteenth centuries, bringing the building to the public's constant attention.[15] The whole complex was situated between Währingerstrasse and Alserstrasse.

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During the second half of the nineteenth century, the hospital was repeatedly expanded while new medical specialties were created. The Sanatorium Löw, later known as Sanatorium Wiener, the anatomical, physiological, and pharmacological institutes, the Röntgen Laboratory of the second Medical University Clinic of Vienna, the new university clinics, and the Röntgen Department of the Viennese Polyclinic were all built in the area around the end of the century. The architectural grouping of medical institutes in the university quarter contributed to the strengthening of the community of medical practitioners and university professors whose reputation had no precedent. The medical faculty of the University of Vienna was the only one that had a considerable number of foreign students who came to study under leading physicians such as the surgeon Theodor Billroth, the anatomist Joseph Hyrtl, and the physiologist Ernst Brücke. In addition, from the early 1870s through the turn of the century, the medical faculties were overcrowded with students, most of whom were coming from previously underrepresented ethnic, social, and geographic backgrounds. The Viennese physicians and their institutions had such a dominant presence in the city that they quickly dominated the Viertel and turned it to a Mediziner-Viertel—the physician's quarter—a designation that slowly replaced the Universitätsviertel—the university quarter. Through a piecemeal but consciously and politically chosen process, the Viertel clustered not only medical institutions and the main university building but soon included the natural sciences as well.

The Chemistry Institute

16 The main university building, however impressive and monumental it was, offered space only for administration offices and teaching facilities. Everyone else had to occupy separate buildings around the same area, realizing the plan for a university quarter. The institute of greatest priority was chemistry (1869–72).[16] The Theresianum, the building where the Viennese Chemistry Institute had been housed since the end of 1860s, proved insufficient for both research and teaching purposes. Its small and cheaply built laboratories could not meet the demands of well-trained chemists, working in the empire's increasing industry, nor chemistry teachers in the *Realschulen*, high schools with a strong focus on technical education. The nature of chemistry was changing drastically. The shift from inorganic to organic chemistry gave way to fruitful experimentation and created the demand for bigger research laboratories. In addition, by being situated in the third district, the institute was far away from Vienna's medical institutions. As the teaching of chemistry was mainly targeted to medical students, the common theme of the Viennese press was the student's complaint of being unable to attend classes given the long distance between the hospital and the Chemistry Institute.[17]

17 Not surprisingly, Joseph Redtenbacher, professor of chemistry, member of the Viennese medical faculty, and director of the Chemistry Institute together with his colleagues voiced their demands for a modern edifice located in the Viertel. The idea of a separate experimental laboratory for chemistry was drawn mainly from the well-established institute (1828) in Giessen, Germany.[18] According to the German tradition, institutes included three spatially diverse facilities under the same roof: lecture halls, laboratories, and an apartment, usually on the ground floor, for the building's caretaker. Often, the director of the institute was offered a free apartment on the upper floor of the building as part of his appointment agreement.

18 Besides supplementing the low salaries of the time, the symbiosis of teaching, research, and residence offered the directors the ability to have absolute control over their institutes and their assistants. Using this as his main argument and paying attention to Redtenbacher's suggestions, Ferstel, the architect of the Chemistry Institute, included in his plans not only the director's residence but professorial apartments as well. During the realization of the project, cost overruns raised questions about the usefulness of this peculiarity. When the institute was

eventually opened in 1872, its impressive Renaissance style reflected not only Ferstel's flexibility to accommodate changes in political power in his architectural style, but also both his and Redtenbacher's ability to incorporate and support the new scientific culture. Large lecture halls, spacious laboratories, and professorial apartments were grouped under the same roof. In their architecture, they embodied the complex task of bringing together different disciplines and therefore, several professors as well.

19 Apparently, the location of the Chemistry Institute in the Mediziner-Viertel reflected not only the political changes that made possible the design of the university quarter in the first place but also changes in the culture of science. The shift was underway from teaching-oriented institutes with limited working space to institutes that combined research facilities with modestly advanced educational laboratories and lecture halls designed to accommodate a large number of students.

20 Redtenbacher was the first who took advantage of the political changes, using the enthusiastic support of the liberals for humanistic education as a lever to alter the culture of chemistry. Eventually, the impressive Renaissance-style Chemistry Institute was located on Währingerstrasse, a minute walk from the university, and it reflected not only Ferstel's flexibility to accommodate changes in political power in his architectural style but also both his and Redtenbacher's ability to incorporate and support the new scientific culture. Large lecture halls, spacious laboratories, and professorial apartments were grouped under the same roof. In their architecture, they embodied the complex task of bringing together different disciplines and therefore, several professors as well.

21 By locating the institute in the Mediziner-Viertel, within walking distance from the Viennese medical institutions, students were able to attend one lecture after the other with no delay. At the same time, the interdisciplinary nature of chemistry was reflected in the education and research of the institute's chemists. Starting with Redtenbacher, all the directors of the laboratories housed in the Chemistry Institute combined pharmaceutical, medical, and chemical expertise. Franz Cölestin Schneider, a pharmacist and medical chemist, and, later, Redtenbacher's successor, clearly stated that the institute should be designed to cover the purposes and needs of pharmacists.[19] The interrelation of chemistry and medicine was also reflected in the journals of the time. For example, one of the most prestigious periodicals, the *Annalen der Chemie und Pharmacie,* combined both pharmacy and chemistry in its title and content. Chemistry was obviously in the

crossroads of pharmacy and medicine. Most of the chemists' teaching was indeed done for medical students. This was evident in the fact that after the institute's establishment, besides the 300 to 400 students of chemistry that attended lectures, 100 more pharmaceutical and medical students crowded into the lecture halls. Although originally designed with the capacity for 140 students in its laboratories and 400 students in the big lecture hall, it turned out to be too small. Chemistry was rapidly expanding and in 1870, a second professorship was already established.[20] The physicists, nonetheless, had to wait a long time to realize their requests for a significant site for their own institute.

The Physics Institute

22 After the revolution of 1848, the Physics Institute (Physikalisches Institut) had been housed in Erdbergstrasse in Vienna's third district close to the Theresianum. In 1855, it was moved to a nearby building that was formerly used as a prison. Both edifices were totally insufficient for the number of students attending physics courses. Furthermore, the Physikalisches Kabinett, the private collection of the Habsburgs' scientific instruments, machinery, and curiosities, was more a museum-like collection that did not satisfy the research needs of the physicists either. As Ludwig Boltzmann later recalled, "We always had plenty of ideas and were only preoccupied with the lack of apparatus."[21]

23 In 1865, Victor von Lang, a Viennese physicist who had worked with Michael Faraday in London, became the director of the Physikalisches Kabinett and acquired new apparatus, but he only slightly improved the institute's extremely modest conditions.[22] In 1872, the medical faculty introduced experimental physics as a new, two-semester course requirement for its students and Lang taught it. His lectures were soon overcrowded. Lang finally arranged to lecture in the Josephinum and moved his apparatus to the big lecture hall, saving his students from commuting.[23] Obviously, there was a high necessity for physics lectures and laboratory work for the medical students. While Lang's course evolved into one of the more well-attended lectures, it consequently provoked the urgent demand for apparatus and the restructuring of the course to meet the needs of the medical students. Shortly after, Lang received an endowment of 4,500 florins, a considerable amount for the time, and an assistant position.[24]

24 Facing similar issues as the chemists, the physicists expected similar treatment. They were after a new institute, preferably located in the Mediziner-Viertel. Amid Redtenbacher's negotiations, Josef Stefan, the director of the Physics Institute, and

Ernst Brück, director of the Institute of Physiology, agreed to establish their own laboratories at the corner of Hörlgasse and Währingerstrasse. Ferstel was once again their architect. In 1872, he submitted his plans of the two institutes as a continuation of the Universitätsviertel project. The longer side of the building was attached to the Chemistry Institute and several halls permitted communication between them. The plan was to facilitate teaching and laboratory work and to encourage research and exchanges among the different institutes. The interconnection of both physics and chemistry to medicine and pharmacy and the dependence of the prestigious medical students on chemists and physicists for their education offered the latter a similarly prestigious location within the university quarter.

25 In the meantime, some natural scientists vigorously reacted to the massive, monumental, and impressive style of the new university. As they argued, a simpler architectural design could better fit the plain and austere nature of their sciences. In a faculty petition on August 4, 1871, they claimed that the new buildings, the Chemistry Institute and the university, by resembling the architecture of the Italian universities did not serve the purpose of furthering the natural sciences. "These flowered elsewhere in the universities of Berlin and Munich, in the Polytechnic of Zurich, in the Collège de France in Paris, and in the Kings College in London, where the exact science can feel comfortable—fewer floors of the same height, several but larger courtyards, and all straight lines fitting to austere requests."[25]

26 One of the most politically flexible architects of his time, Ferstel for once faced resistance from conservative scientists and not politicians. Caught between obstinate natural scientists and the crash of Austria's stock market in 1873, Ferstel's plans for the Physics Institute were never realized. Instead, in 1875, the university purchased a block of flats and converted it to an institute. The Physikalisches Kabinett and Stefan's Physics Institute moved into the four-story building located in Türkenstrasse 3, a short side street crossing Währingerstrasse. Under the same roof on the third floor was located the Institute for Physical Chemistry. In 1867, Redtenbacher, Lang, and Stefan proposed the establishment of a professorship of physical chemistry. At the time, Josef Loschmidt was working on gas theory, combining chemistry and physics in his research. He collaborated closely with Stefan and used the facilities of the Physics Institute when it was still housed in Erdbergstrasse. Thus, it is not surprising that the physicists suggested Loschmidt as the most appropriate person for the position in physical chemistry.[26] He soon became director of the Institute of Physical Chemistry and his lectures

attracted 100 to 120 students regularly. In his laboratory courses, Loschmidt had around twenty students as trainees and his physics course, designed for pharmacists, had the highest attendance.

27 The building in Türkenstrasse lacked basic features of a modern science institute. "The inner space was not designed as a laboratory," Karl Przibram later recalled. The ceiling beams were so rotten that they seemed as if they had been chewed by termites. As the daily *Arbeiterzeitung,* a Social Democratic paper, satirized the shabbiness of the building, "Once again, a student has registered in the Physics Institute on the Türkenstrasse; unhappiness in love is said to be the motive for the deed." Later, when Lise Meitner entered the University of Vienna and attended a physics course at the institute, she expressed fear that if a fire broke out, very few could actually survive.[27] Although insufficient for the research that modern physics demanded, the collegial atmosphere at the Physics Institute balanced the inadequacy of the space. The Viennese physicists were fortunate to empower their relations and acquire a sense of community through their regular gatherings at the house of Franz Serafin Exner, director of the II. Physikalisches Institut.[28]

Franz Exner's Circle and His Ethos of Working in Physics

28 At the turn of the century, the physics community was affected by the reorganization of its institutes and big cuts in their finances.[29] In 1902, the Physikalisches Kabinett was renamed I. Physikalisches Institut, and Lang remained its director. The Physikalisches Institut that Stefan directed until 1894 was renamed Institut für Theoretische Physik and Ludwig Boltzmann became the director.[30] Loschmidt's Institute of Physical Chemistry was renamed II. Physikalisches Institut and Franz Serafin Exner took over the directorship. Given the reorganization of the physics institutes, Boltzmann's apartment in the building at Türkenstrasse was ceded to Exner's institute as working rooms.[31] The collection of scientific instruments formerly belonging to the Physikalisches Kabinett was transferred to Exner's supervision.[32]

29 At the time, Exner was *Ordinarius Professor* at the University of Vienna and one of the most prominent experimental physicists, in charge of a considerable number of students. Research on atmospheric electricity, color theory, spectral analysis, and radioactivity occupied his interest. Open to scientific challenges, he was the first to report Konrad Röntgen's discovery of x-rays on January 7, 1895, to the Institute for Physical Chemistry in Vienna.[33]

30 Exner's earlier career started in Strasburg. Disappointed by the monolithic culture of the physics community there, he returned to Vienna. As he complained, "Day after day from 8:00 a.m. to 10:00 p.m., physics and again physics, this no decent human could stand."[34] What Exner missed, as Berta Karlik and Erich Schmid explained, was Viennese culture and art, especially music, and it was this culture that Exner maintained in the physics community of Vienna upon his return. As best described by his assistant Hans Benndorf, Exner established a new ethos for working in physics:

> A circle of like-minded friends, we surrounded our admirable and beloved teacher as a big family. The most wonderful and also cheerful hours of the day were the tea at the institute during late afternoon, where the "little father," this is how we called him among us, with his pipe in his hand, was regularly presiding. There we were talking about God and the world, often passionately discussed, and about controversial scientific questions. And we had good arguments with him, and he could bear any contradiction as long as it was not personal. Also, we never felt his superiority and he always seemed to be another youth among the young. We are indebted to those hours for the important stimulation of our own work.[35]

31 Przibram recalled the same picture of Exner in his white lab coat and the inevitable pipe in his hand: "The picture reflects something of the coziness that ruled the circle in those days."[36] Passionate debates on science and politics and Exner's narratives of his long trips to Greece and Asia often accompanied by music took place at his home on Währingerstrasse 29 every Saturday evening.[37] In his welcoming house right in the heart of the Mediziner-Viertel next to the Josephinum, Exner cultivated the Viennese ethos of collaborative work in physics and mentored nearly all the experimental physicists in Austria. His circle included Hans Benndorf, Egon von Schweidler, Stefan Meyer, Maria Smoluchowski, Friedrich Hasenöhrl, Karl Przibram, Felix Ehrenhaft, Erwin Schrödinger, and Hans Thirring among others.

32 Exner's circle[38] or Exner's school,[39] as it was known, promoted not only the integration of physics with Viennese culture but also the work of women in the field. Exner was among those professors who in 1893 formed a committee to support women's admission to the University of Vienna.[40] Due to his strong beliefs in the liberal, bourgeois ideal of education, Exner's support of women's education does not come as a surprise. To Austrians, the figure of his father, Franz Exner, embodied the liberal pedagogical reforms proposed in 1840. Deborah Coen argues that "While Exner's reform plans of 1848–9 were to be no more than guidelines,

they remained the standard, the ideal, against which Austrians judged the success or failure of the empire's schools for over half a century."[41] His sons inherited their father's authority.

33 As Franz Serafin Exner acknowledged in 1908 participating in the debate for the reform of the middle-school education, "The traditions of the author of the organizational proposal of 1849 are still alive in me." His brother, the physiologist Sigmund Exner, tried very hard to have an impact on the medical reforms in education when in 1899 his friend von Hartel became minister of culture and education. To reconcile the ideals of liberal education with the concerns of socially progressive critics, he took a positive stance on the issue of women's training as physicians. Although believing that women tended to focus more on the exams than on utilizing their education, he had never had a problem with teaching men and women together. His wife, Emilie von Winiwarter, was also an activist for academic education for women. From 1901 to 1906, she was president of the Viennese Women's Employment Association (Frauen-Erwerbverein), an association which was fighting for the entrance of women into appropriate professions.[42] Among those professions that Emilie considered suitable for women was that of a pharmacist as it allowed women to work at home and preserve their ideals of maintaining a good and happy family. Preserving their liberal ideas, Emilie and the Exner family, were actually giving a right to education and a voice in the political domain to their progressive critics.

Women's Admission to the University of Vienna

34 During the 1860s, the economic distress in imperial Austria forced many women to search for employment. For example, the majority of workers in the textile industry were women.[43] Proliferating in these new professions, lower-middle-class women needed special training in new technologies. In 1867, the Viennese Women's Employment Association (Wiener Frauen-Erwerbverein) emerged to cover such needs. Its leader, Iduna Laube, having the absolute support of the association, soon established a school for sewing linen and a commercial school with courses in embroidery, lace-making, dressmaking, and housekeeping. In 1871, the association founded an academic school in the form of a *höhere Bildungsschule,* providing four years of practical training. It was primarily established by upper-class women—Emilie Exner among them—concerned with facilitating women's "entry into female white-collar employment," who ran the school.

35 Although the association vehemently stressed women's right to education, it did not have any further political aims. The suggestion to establish a gymnasium for girls (a school equivalent to that for boys preparing for university studies) was considered so revolutionary that none of the association's women was willing to pursue it. Without challenging the conventional female identity of a housewife, their goal was to professionalize traditional female activities. A number of other vocational schools followed that of the association's, but not one of them was "suited to raise the level of education of girls from the middle-class intelligentsia and therefore to open profitable sources of income to them," argued Marianne Hainisch, one of the prominent feminists of the time.[44]

36 It was not until 1888 that the Association for Extending Women's Education (Verein für Erweiterte Frauenbildung) was founded as an attempt to support the establishment of a gymnasium for girls. The goal was not modest since the school would be the first one in Vienna to raise girls up to the academic standards necessary for university entrance. Thus, along with a petition for the establishment of the school, the association handed to the imperial government an appeal for the admittance of women at the arts and medical faculties of the University of Vienna. This was signed by 3,644 women, members of a number of different Viennese groups, such as the Association of Housewives (Hausfrauen Verein) with 2,601 members, and the Association of Teachers and Nursery School Teachers (Verein der Lehrerinnen und Erzieherinnen) with 600 members. Women scientists from Germany joined the campaign and offered their experiences as invited speakers at the association's activities. The ophthalmologist Rosa Kerschbaumer and the surgeon Agnes Bluhm were among the first to support Viennese women's right to education. The right to enter the university as full students was the pivotal feminist demand, so central that it was presented as self-evident in the feminist discourse of the time. "We believe," read the petition of 1890, "that women's right to scientific education needs no further evidence but women's self functionality and opportunity."

37 In a certain sense, the appeal of the Association for Extending Women's Education was limited to a few thousand middle-class Viennese women and probably directly affected only those who had the means to pursue private education. In another sense, however, their education reform campaign shaped the ideals of a number of young women who held different personal expectations concerning their university admission.

38 The association and its demands provided a crucial impetus for the transformation of Viennese culture and society. A new, collective female identity emerged and traditional meanings of sexual difference were challenged. Since the Austrian government did not respond to the feminists' requests for educational changes, the association opened up a private gymnasiale Mädchenschule in 1892 based on the curriculum of the boy's gymnasium. Prominent intellectuals and officials such as the director of Vienna's training institute for gymnasium teachers, Emmanuel Hannak, supported women's educational initiative. Setting high standards from its establishment, the school was equivalent to the akademisches Gymansium, the school preparing boys for higher education.[45]

39 The school was not established in a theoretical vacuum and apart from the feminist discourse of fin de siècle Vienna. The investigation of early Viennese feminist movements by Harriet Anderson changes the conventional picture of Vienna as merely the city of Sigmund Freud and Gustav Klimt, of music, art, and smoky coffeehouses crowded by the Viennese intelligentsia. "There was in fact a flourishing culture of political opposition in which men and women worked together for a vision of a society which would not dehumanize its members but permit them to go 'in purity' through life, without concealment and without regret."[46] The Viennese feminists played a crucial role in the formation of this culture of political opposition. In the last decade of the nineteenth century, an organized political feminist movement emerged in Vienna, interwoven with the broader cultural changes. The interplay of different cultural and philosophical critiques led to an increasing political awareness. Women became part of the political game, bringing into focus ethics and sexual morality as well as women's rights and equal opportunities to education. Two autonomous feminists groups, the General Austrian Women's Association (Allgemeiner Oesterreichischer Frauenverein) and the League of Austrian Women's Associations (Bund Oesterreichischer Frauenverein) marked the Viennese feminist scene.

40 Auguste Fickert, a primary school teacher with a strong personality and radical ideas, was the leading figure of the women's association. Her views, extreme for the time, included the argument that changing external conditions alone would not be enough in changing women's lives. Better wages and equal rights for women at work and at home were necessary but insufficient without the "merging of intelligence with morality."[47] Both the women's association and Fickert emphasized women's education, their intellectual awakening, and the raising of their consciousness.

41 On the other hand, Marianne Hainisch and the League of Austrian Women's Associations (Bund Oestereichischer Frauenverein) that she established in 1902 had less ambitious and radical goals. The wife of a cotton factory owner, Hainisch founded the league as part of the international feminist network based on the principles of the International Council of Women. It functioned as a public relations body of the Austrian women's movement and united a number of associations, attempting to support and not compete with them. Adopting the discourse of equality and difference, Hainisch fought for the equality of women and men, stressing their differences without challenging the status quo of power relations. One of the strongest advocates for a women's gymnasium, she envisioned education as women's means to enter better professions. Hainisch and the league strongly emphasized their apolitical character, and they argued less in terms of women's rights and emancipation than in terms of morality. Despite their differences, Hainisch and Fickert had one common goal, that of women's *Bildung*. Along with the Association for Extended Women's Education, the league organized a number of talks inviting male intellectuals to speak about women's rights from a philosophical, historical, or juristic point of view.

42 Men played a significant role in the middle-class women's movement. A number of university professors, artists, and left-wing middle-class intellectuals supported the women's movement, spoke at their meetings, joined their associations, and offered their expertise for the improvement of women's education. In 1900, the historian Ludo Moritz Hartmann and the Union of Austrian University Teachers initiated an association known as Athenäum: Association for the Holding of Academic Courses for Women and Girls. Julius Tandler, an anatomist at the University of Vienna and a main figure in the Social Democratic party later in the 1920s, offered free lectures. The zoologist Carl Brühl lectured on natural sciences in a seminar room flooded with women. The philosopher Friedrich Jodl was one of the most passionate supporters of women's education along with his wife Margarete Jodl, president of Vienna Women's Club (Wiener Frauenclub), a cultural network of upper-class Viennese women.[48]

43 Surprisingly, of all the physics communities in Austria, only Vienna's played an essential role in promoting women's education at the academic level.[49] Victor von Lang, firmly convinced that women should not be held back from studying at the university, welcomed them to his lectures before they were officially accepted as formal students.[50]

44 Ludwig Boltzmann supported the Association for Extended Women's Education with his full membership. In the mid-1870s, when Henriette von Aigentler, the woman who later became his wife, was refused permission to unofficially audit lectures at the University of Graz, Boltzmann encouraged her to appeal.[51] Although Aigentler's appeal was successful, she was able to audit classes only for one semester. The following semester, the philosophical faculty approved a rigid rule to exclude women from their lectures at the University of Graz.[52] Their daughter, Henriette Boltzmann, later became one of the first women to take the *Matura*—exams for university entrance—in 1901.[53]

45 The above examples of the support by academics of women's right to be admitted to the University of Vienna and for attempts to reform their everyday lives indicate that in the late nineteenth century, the forging of a new identity for women was underway. This identity was generated by feminist discourse and was documented in journals such as the *Dokumente* and the *Neues Frauenleben,* both publications of autonomous feminist groups. The feminists attempted to alter women's lives and envisioned them as socially active intellectuals. Thus, in 1896, when women were finally granted the permission to sit for the *Matura*, they embraced the chance. Since the only women's gymnasium in existence did not have the license to set up its own exam, women had to sit as *Externisten* (outside students) in one of the gymnasiums for boys under strenuous and unpleasant conditions. "We were fourteen girls in all," Lise Meitner recalled, "and took a not altogether easy exam (only four of us got through) at a boys' school, the akademisches Gymnasium in Vienna."[54] Despite the frustrations, women were finally accepted to the philosophical faculty of the University of Vienna in 1897 and three years later, the doors of the medical and pharmaceutical faculty of the university opened for them.[55]

46 Soon after their admission to the University of Vienna, the number of female students increased beyond expectations. In the first academic year, three women were registered as matriculated (*ordentliche*) and 34 as non-matriculated (*außerordentliche*) students.[56] Among the first three was Elise Richter, later the first female doctoral student (*Dissertantin*) in the philosophical faculty.[57] Coming from a wealthy upper-class family of the Viennese Jewish intelligentsia, Richter grew up in a disciplined but cultured environment. Her father was a medical doctor

who assured her private education. Elise took the *Matura* as *Externistin* and studied romance languages and literature. In 1907, she became the first *Dozentin* (lecturer) at the University of Vienna.

47 Richter's background is not exceptional among the women who chose to enroll in the university. The women who entered the University of Vienna and its surrounding institutes were mainly from the prosperous middle and upper classes. The only school with official state recognition to prepare women for academic studies was the private gymansiale Mädchenschule that the Association for Extending Women's Education founded in 1892. It was not until 1906 that the school was able to set up its own *Matura* exams and changed its name to Mädchen Obergymansium (Upper Gymnasium for Girls).[58] Receiving no subsidy from the Austrian government, the school depended on its wealthy pupils, most of them coming from the families of businessmen, civil servants, and the Viennese upper class. Since Jews were among the leading economic force in Vienna, 35 to 40 percent of the students were of Jewish descent. In the early days of the school, classes took place in the Natural History Museum. Despite the criticisms of radical feminists for its elitist character and despite the hostility of the educational authorities, the school soon flourished, partly due to the contributions of patrons. One of the most important patrons of women's education was Marie von Najmajer, who in 1898, just a year after women's admission to the university, set up an annual grant for full-time university students of 150 florins. In 1901, she donated an additional 40,000 kronen to support the school.[59]

48 Even though the academic elite viewed female students as intruders, women won admission to the medical faculty in 1900. Thus, during the academic year 1900–1901, the total number of female students substantially increased. There were 31 matriculated students on the philosophical faculty and 10 on the medical faculty, while the number of the non-matriculated students for the two faculties was 87 and 25 respectively.[60] (See Table 01/3.)

49 During the academic year 1897–98, the ratio of women to men was 1:183; during the academic year just before World War I, it had fallen to 1:12. Within the first 17 years of women's admission to the University of Vienna, their number had multiplied 21.5 times. (See Chart 01/3.)[61]

50 Despite the steady increase of female students, their number in relation to the inhabitants of the city of Vienna was about 1:36,000 in 1913–14.[62] Considering the fact that the university was accessible only to the women of the Viennese elite

who had the finances to pursue their secondary education at the Mädchen Obergymnasium, the above ratio is not surprising. In 1900, the Ministry of Culture and Education, after conducting an inquiry about the need for a state gymnasium for girls, rejected the feminists' request and established instead a *lycée*, a school preparing women for more "feminine" professional posts.[63]

What the above numbers indicate, nonetheless, is that the feminist movement and its members were not intellectual or political outsiders. They had an influence on women's choices, decisions, and lives. For instance, despite the modest beginnings of some feminist groups, the total membership of the league reached 40,000 women in 1914.[64] Whatever expressions were used and whatever goals were anticipated, feminists and their supporters had forced a rearrangement of Viennese social institutions. Admission of women to the university was not the result of a natural process, but was engendered by the persistent efforts of the feminists. It clearly emerged out of a discourse that constructed a collective identity for upper- and middle-class Viennese women. 51

Women Enter the Field of Physics

After their admission to the University of Vienna, women were welcomed to physics lectures and laboratory courses. Out of 32 Austrian women registered in the University of Vienna for the academic year 1897–98, 10 took classes in physics.[65] In 1903, Olga Steindler (1879–1933) was the first to complete a dissertation in physics. As a daughter of an attorney, Steindler studied at the private Mädchengymnasium of the Association for Extended Women's Education and took her exams as *Externistin* in Prague. In the fall semester of 1899–1900, she registered at the philosophical faculty and studied physics and mathematics. In her *Rigorosen*, the oral examination required for the degree, Exner and Boltzmann were her examiners.[66] Aware of women's need for emancipation, Steindler lectured at the Athenäum while still a student. It was at the University of Vienna that Steindler met Felix Ehrenhaft, Exner's *Assistent* and member of his circle, whom she married in 1908. They were the same age and shared a strong interest in physics, culture, and politics. Steindler devoted her career to women's *Bildung,* serving as director of Handelsakademie (Business Academy) and becoming one of the first female school directors. 52

The same enthusiasm for physics brought a second woman, Lise Meitner, to the Physics Institute at Türkenstrasse. She graduated in 1906, the same year as Selma Freud; the latter, however, did not pursue any further work in the field. 53

Meitner and Freud shared a work room in the institute at Türkenstrasse.[67] After her graduation, Meitner stayed one more year at the institute and worked with Stefan Meyer on radioactivity research in a room next to Przibram's. In a well-documented biography, Ruth Sime highlights the meaning of the ethos and collegiality of Exner's circle in Meitner's career:

> One of Lise's fellow students, Karl Przibram, remembered Exner for his contagious enthusiasm and for the community spirit that went far beyond the usual relationship between teacher and students. This sense of community was essential for Lise in finding her way. She had come to the university on her own, very conscious of how few women there were and how visible she was, how some of the men went out of their way to be pleasant and others, just as conspicuously, did the opposite.[68]

54 Slowly and persistently, women were engaging in the physics community. Apparently, they were not only accepted in lectures, but they were also assigned work space within physics laboratories, as Freud's and Meitner's trajectory illustrates. Marking the transition from exclusion to integration in fin de siècle Vienna, women gained access to the University of Vienna and to almost all of the scientific institutes in the Mediziner-Viertel. As Table 02/3 illustrates, from the fall semester of 1897–98 to the spring semester of 1913–14, women were actively interested in traditionally male-dominated fields.[69]

55 During the first academic year, 31.3 percent of the total number of the enrolled female students chose the field of physics. In chemistry the percentage was 28.1 and in mathematics 37.5 for the same year. These percentages were very close to 40.6 percent for pedagogy and not far off from 56.3 percent for philology, fields conventionally characterized as female ones.

56 By being able to attend university studies, women were also able to enter the cultural and physical space that surrounded the university building. A further argument to be made is that the Mediziner-Viertel serves as the midpoint for understanding how women assimilated themselves into the academic world, especially the physics community, and became part of it instead of invisible outsiders. It was in that physical and intellectual space that women associated with their male colleagues, exchanged ideas, and acquired the *Bildung* that both feminists and Social Democrats valued and aspired to so strongly. The city stood

not merely as the social and political setting for the development of scientific institutions, but it also molded both scientific knowledge and a hierarchy on those that possessed it.

The Mediziner-Viertel as a Laboratory in the Field: The Coffeehouse Culture

57 One could read the history of the sciences in early-twentieth-century Vienna as a chapter in the urban reconstruction of the city, the creation of the Mediziner-Viertel, and the architectural grouping of diverse laboratories. Scientists of fin de siècle Vienna were strongly attached to the locality of their institutes and the surrounding culture. The face-to-face interaction of researchers with various experts created a scientific network enmeshed in the cultural life of the city, a laboratory in the field. Apparatus for educational demonstrations, instruments for experimental use, and theoretical ideas of different scientific disciplines crossed Währingerstrasse the same way that scientists crossed their institutional boundaries. Studying the importance of the Mediziner-Viertel in the cultural and scientific scene of fin de siècle Vienna, one encounters both the broader spectrum where knowledge was produced and circulated in the city and also those involved in the production.

58 The coffeehouses in the area particularly provided them with a space for social interaction where endless discussions on science enforced feelings of collegiality. The role of coffeehouses as locations of scientific exchanges, as sites of learning and even, in the case of eighteenth-century England, as spaces where scientific principles and experiments were turned into commodities to be sold by philosophers, has recently drawn the interest of historians of science.[70] Conversations on chemistry and the phlogiston, for example, took place in the eighteenth-century London coffee shop where the Coffee House Philosophical Society held its open conversations. As Ian Golinski argues, the coffeehouses were known as sites of "free flowing and open discourse" and served both the goals of the group of holding egalitarian type of conversations and the ideals of science as public culture.[71] With each coffeehouse attracting a particular clientele, in the latter half of the eighteenth century, Benjamin Franklin spent his Thursdays as a colonial agent in London at St. Paul's Coffeehouse, the Club of Honest Whigs, a political club with overtones of libertarian politics and a house for many of the members of the Royal Society and the Society of Arts.[72]

59 In Vienna, coffeehouses have been associated with the city's cultural preeminence at the turn of the nineteenth century and have been portrayed as clubs of philosophical, political, and artistic circles. They were the spaces that maintained the cohesiveness of the Viennese elite and functioned as institutions where the Viennese intellectuals mingled with the professional elite and shared ideas and values with each other. Since 1880, painters had their *Stammtisch* in Café Sperl; Victor Adler, the leading figure in the social democratic party and his fellows met at Café Griensteidl; the political critic and radical intellectual Karl Kraus was a habitué of Café Imperial; and the architects met at Café Museum.

60 Between 1907 and 1912, Philip Frank, Hans Hahn, and Otto Neurath, the "first Vienna Circle," gathered at Café Central, usually on Thursdays. Ulla Heise argues that without these coffee shops, most of which were located in the inner city, the Viennese Sezession probably could not have existed nor made their significant contribution to the literature of 1900 Vienna.[73] This tradition continued in the 1920s and 1930s. In exile, Bertolt Brecht singled out the Viennese cafés among all its highlights: "As every newspaper reader knows, the city is built around a few coffeehouses where the population sits together and reads papers." The Viennese writer Stefan Zweig called the coffeehouse "the best school of everything new."[74]

61 Symbolic of a carefree existence, the Viennese coffeehouse also carried a paradox: it reflected the hard realities of life in Vienna at the same time that it seemed to embody a relaxed way of spending a day, by reading the papers and enjoying the delicious pastries. Due to the housing shortage, the working-class apartments were small, inadequate, and unbearable, especially during the cold Viennese winters. Coffeehouses offered a pleasant and warm environment throughout the day.[75] The same architectural absurdity led the physicists, working at Türkenstrasse, to the charming coffeehouse at the corner of their laboratory, even though it was less impressive than the coffeehouses of the first district. It was there they contributed to the confluence of scientific disciplines and discussions. Of that "idyllic time," Przibram later recalled with nostalgia that "the young generation of physicists can hardly imagine the passion of the debates, echoed in those days particularly in the above mentioned coffeehouse."[76]

Women Enter the Field of Radioactivity

62 In the crossroad of physics, chemistry, and medicine, women found it convenient to enter the field of radioactivity, taking advantage of its interdisciplinarity. From 1910 to 1920, eight women out of 48 authors published work in the *Mitteilungen*,

the annual bulletin of the institute. Taking into account the canonical stories of women's invisibility in the physical sciences, the percentage of women authors (16.7 percent) is surprising.[77] Each of those women came into radioactivity by a different route. Each of them had a different life pattern, however, which embodied the local circumstances and was affected by the spatial relations developed in the Mediziner-Viertel. Women's involvement to radioactivity research during the 1910s had to be seen as an urban practice, as a flow of trafficking materials and practices, which linked the confined space of the laboratory to other sites of knowledge production and sites of consumption. The women's everyday life in the local context of the Viertel and the city in general influenced the science they were able and most importantly, allowed to produce.

63 For example, to enter the institute, Friederike Friedmann used her experimental skills in physics. Her research topic was testing the theoretical hypothesis concerning the variations in the range of alpha particles. In the early days of radioactivity research, the main problem was to determine the chemical identity of the new elements, define their properties, and explain the decay-series transitions. One way to determine atomic weights was by calculating the number of alpha transitions from the known elements such as uranium, radium, and thorium. Thus, the properties of alpha radiation were essential in the identification of elements. Friedmann made an experimental investigation of the variations in the range of individual alpha particles emitted from a source. The fact that all alpha particles did not penetrate the exact same distance in air was tested statistically by Karl Herzfeld in 1912.[78] In 1913, it was Friedmann who offered an experimental confirmation of Herzfeld's theoretical results for the case of polonium.[79]

64 In order to gain greater technical expertise for her experimental work, Friedmann sought further education at the Technische Hochschule Wien. To Friedmann, the city could afford an important opportunity to access the technicians and their knowledge, which was needed for the background work on her scientific research. The Technische Hochschule was located walking distance from the Radium Institute at Karlsplatz, on the exact opposite side of Ringstrasse from the university. Although women had already been accepted at the university for more than a decade, the Technische Hochschule was still a space of tension and transition as it remained closed to female students.

65 Women's technical education definitely challenged the dominant discourse of womanhood in Vienna in the 1910s. In 1913, the Ministry of Education issued a restrictive decree, allowing the Technische Hochscule to accept women as non-

matriculated students and only for some courses that were required for teacher's exams. The same year, Friedmann applied as a non-matriculated student for a course on electrotechnics. Despite the ministry's decree, her application was rejected. Friedmann's resistance to the space restrictions imposed upon her life, both personal and professional, yielded results only in the academic year 1918–19, when women were finally accepted as matriculated students at Vienna's Technische Hochschule. For example, Elisabeth Kara-Michailova, one of the women who entered the institute in the early 1920s, was able to follow courses at the Polytechnic from 1921 to 1923 in electrical and radio engineering and was also admitted to practical training in these subjects.[80]

66 Crossing their space boundaries enabled women to map themselves differently within new spaces. They tried to use the city as a resource for gaining access to and maintaining their presence in public spaces such as the laboratory or elsewhere in the university. For some, such as Stefanie Horovitz and Marietta Blau, the city provided ready access to the Radium Institute and to the network of science-related institutions in the Viertel. City life and social relations offered women visibility and opportunities to develop their professional careers.

Stefanie Horovitz: Dispelling the Myth of the Invisible Assistant

67 For Stefanie Horovitz, it was her knowledge of chemistry, her connection to Lise Meitner, and the topography of the Mediziner-Viertel that opened the door to the Radium Institute. By the end of the 1910s, a considerable number of chemically non-separable pairs or groups of radioelements had begun to accumulate very rapidly. As Frederic Soddy put it colloquially, "Their atoms have identical outsides but different insides." These elements, identical in their whole chemical character and not separable by any method of chemical analysis, were later called isotopes.

68 In 1913, Soddy succeeded in placing all the known radioelements in the periodic table, despite the fact that there were more of them than places available. He did so by locating more than one radioelement in the same box based on the elements' atomic numbers. Even though these elements belonged to different decay series they were chemically inseparable. In order to confirm the existence of these identical and at the same time different substances scientists had to determine and compare the atomic weights of the isotopic elements.[81]

69 The experimental work of determining atomic weights was painstaking and time consuming. The substances to be weighed had to be capable of isolation in a pure state—a challenging task—and the experimenter needed to be in a position to determine even the minutest quantity of the substance that might get lost during the quantitative experiment. The world's leading expert in the field was the chemist Theodore Richards, professor at Harvard University and Nobel laureate in 1914 for the accurate determinations of the atomic weight of a large number of chemical elements. Otto Hönigschmid, another atomic weight expert from Vienna, was asked by both Soddy and Kasimir Fajans to undertake atomic weight experiments using lead from radioactive sources. He repeated the experiments, employing the same Harvard method with the advantage of quartz apparatus and using lead from Joachimsthal pitchblende. The transfer of knowledge from Harvard to Vienna does not come as a surprise. Hönigschmid had spent 1909 working with Richards in Boston, hoping to learn his techniques. In the fall of 1910, he returned to Vienna to undertake work at the Radium Institute. While carrying out numerous fractionations and crystallizations, he determined the weight of radium and prepared a radium standard, which became the official substitute to the original in Paris.

70 Performing atomic weight experiments was not a task Hönigschmid could conduct alone given that, in 1911, he had already accepted the directorship of the laboratory for inorganic and analytic chemistry in the Deutschen Technischen Hochschule in Prague, where he had also become an *Ordinarius* professor.[82] In January 1914, he asked Lise Meitner, who was already in Berlin, whether she knew of someone in Vienna qualified to assist him in his atomic weight determination project.[83] The advantage of acting within a space such as the Mediziner-Viertel, where scientific institutes were within walking distance of each other, was that the few women in science were very visible. Meitner had worked at the Physics Institute at Türkenstrasse, and she remembered Stephanie Horovitz, who was studying under Guido Goldschmiedt at the second Chemistry Institute nearby. Thanks to Meitner's recommendation, Horovitz was offered the job. As Hönigschmid wrote to Meitner a few months later, "I am sending you greetings from Miss Horovitz, who does not believe that you still remember her. I have just argued with her about that."[84]

71 Like Meitner, Horovitz was a Jew. She was born in Warsaw in 1887 and moved to Vienna with her family in 1890. In 1913, Hönigschmid approached her when she was a young chemist who had just graduated from the University of Vienna. Wet

chemical techniques and the experimental identification of atomic weights were definitely within her capabilities and, by June 1914, Horovitz and Hönigschmid were working closely together. "Miss Horovitz and I," Hönigschmid informed Meitner, "worked like coolies. On this beautiful Sunday, we are still sitting in the laboratory at 6 o'clock."[85]

72 Horovitz and Hönigschmid purified lead out of 100 kg of lead sulfate from the Joachimsthal pitchblende, a time-consuming and meticulous assignment. The atomic weight of radioactive lead was found to be 206.73, lighter than ordinary lead (207.21). On May 23, 1914, Hönigschmid presented their results at a congress of the Bunsen Geselschaft in Leipzig. Conscious of the importance of their work, they immediately sent their article first to the *Monatshefte für Chemie* instead of the institute's *Mitteilungen* and, shortly afterwards, they published a version in the French *Comptes rendus.* As Badash points out, Hönigschmid and Horovitz offered the most convincing confirmation of the Harvard work. For the next two years, they continued to copublish on the atomic weights of uranium, thorium, and ionium.[86] In addition, their research showed that ionium was not a separate element but just an isotope of thorium.

73 Accounts of Hönigschmid's and Horovitz's collaboations always present her as his "protégé," "research student,"[87] or simply as his "student"[88] who assisted him in determining the atomic weight of radioactive lead. Attempts to address the imbalance reach the other end of the spectrum by references to the results as "hers" even though copublished papers are cited.[89] To disentangle the politics of collaboration between men and women who work in partnership proves to be a difficult undertaking. Common publications do not reveal who actually took the lead in each project, who was the assistant, and who was assisted. In the case of the Hönigschmid-Horovitz cooperation, there is no doubt that he was the mature partner and project leader. He introduced Horovitz to experiments of atomic weight determination and welcomed her both to the Radium Institute and, it seems, to his laboratory in Prague. In a letter to his friend Max Lembert, Hönigschmid forwarded Horovitz's greetings: "With best wishes from Fräulein Doctor Horovitz, the beautiful graduate." Without a doubt, Horovitz was more than an able assistant who followed instructions by her mentor.

74 The way Hönigschmid described to Meitner his research project in 1914 is revealing for its emphasis on Horovitz's input in the work. "*We* now isolate lead from pure Joachimsthal pitchblende . . . *We* hope that in the next two weeks before the holidays *we* will analyze these preparations of lead . . ."[90] As a chemist,

Horovitz brought her expertise from the Chemistry Institute to the neighboring Institute for Radium Research and entered the field of radioactivity as a young researcher instead of a student. In his Nobel lecture in 1922, Frederick Soddy acknowledged Horovitz's presence as Hönigschmid's partner in quite the reverse to the account of Richard's team in Harvard. "Simultaneously, work on lead from uranium minerals by T. W. Richards and his students at Harvard, and by Hönigschmid and Mlle. Horovitz, gave values all below the international figure."[91]

Nevertheless, the end of the First World War also brought an end to the Hönigschmid-Horovitz collaboration. He accepted a position at the University of Munich, and she left the institute to return to her hometown in Poland. Long afterwards, Kasimir Fajans informed Elisabeth Rona that, "Stefanie moved there [to Warzawa] to join her married sister after the First World War, after her parents had died in Vienna. She was not active in chemistry, and she and her sister were liquidated by the Nazis in 1940." Unable to bear the burdens imposed by the Nazis, Hönigschmid and his wife committed suicide on October 14, 1945.[92]

75

Marietta Blau: Taking Advantage of a Trafficking Material

If Horovitz's involvement in radioactivity research serves as a clear example of women's entrance into the field because of the essential interplay of chemistry and physics, the case of Marietta Blau points out the significance of medicine and clinical radiotherapy to radiophysics. Once again, the Mediziner-Viertel functioned as a locus of scientific practice, shaping Blau's opportunities for interdisciplinary research. Her expertise on radium was her vehicle to an advanced career.

76

Blau was born in fin de siècle Vienna as the third child of an upper-class Jewish family. Her father, Markus Blau, was a lawyer in the Kaiser's courts and an important music publisher. Her mother, Florentine Goldenzweig, was the sister of Josef Weinberger, the main publisher of Gustav Mahler's works in Europe. During her childhood, she attended some of the best Viennese schools and, in 1905, was sent to the private Mädchen Obergymansium, the only school with official state recognition to prepare women for academic studies. In 1914, when the young men were drafted and women had more access to education, Blau enrolled at the University of Vienna to study physics and mathematics. For two semesters, she conducted her *Praktikum* (practical training) at Exner's Second Physics Institute and eventually moved to the Institute for Radium Research.[93] In 1918, Blau submitted her dissertation on the absorption of diverging gamma rays—"a

77

radiological subject"—and her first paper appeared both in the annual bulletin of the Radium Institute and in the *Sitzungsberichte* of the Austrian Academy of Sciences. [94]

78 Blau's research topic turned out to be important in the clinical treatments of cancer. Discovered by a French physicist, Paul Villard, gamma rays had occupied the interest of the radioactivity community since 1900. In 1904, Marie Curie performed the first gamma radiography and in 1914, Rutherford showed that gamma rays were a form of electromagnetic light.[95] Eventually, it was Blau's radiological research topic that opened the door of Holzknecht's radiological institute for her. As Blau put it in a later curriculum vitae, after defending her thesis in 1919, "I conducted theoretical studies and at the same time was a research assistant at the Laboratory for Medical Radiology at the Holzknecht Clinic, where I studied medical physics."[96]

79 Holzknecht's clinic was located at Vienna's Allgemeine Krankenhaus, not far from the institute and within the limits of the Viertel. Their physical proximity played a significant role in facilitating the path of radium and the transferring of personnel from Boltzmanngasse to the neighboring medical facilities. For instance, Meyer helped the physician Gustav Riehl set up the Radium Station of the Allgemeine Krankenhaus and provided the expertise of his colleagues for the preparation of radium for therapeutic use.[97] Available to all the clinics and departments of the hospital, the Radium Station, along with Holzknecht's Röntgen Laboratory, provided a network of medical practitioners to the Institute for Radium Research. Blau simply took advantage of these connections in order to maintain her work on radioactivity and straddled the boundary of medicine and physics for the rest of her career.

80 In 1921, Blau left Vienna to accept a position as a physicist in Eppens and Co., which manufactured x-ray tubes in Fürstenau, Germany. A year later, she moved to the Institute of Medical Physics in Frankfurt am Main where she worked as a research assistant.[98] For more than a year, she instructed doctors in radiobiology while she conceived and elaborated a theory on the effect of x-rays on biological objects. At that time, the Frankfurt Institute was Germany's epicenter of target theory, which described the impinging of radiation on living tissues as particles hitting a target. The theory's aim was to use radiation to probe the structure of the organic world.

81 Blau played an instrumental role in developing the statistical analysis of biophysical processes that constituted "hits," which was the main research project of Friedrich Dessauer, the director of the institute.[99] Working with Kamillo Altenburger, she studied the number of "hits" that were required for a biological process to occur. Her research career in Germany was interrupted abruptly in the fall of 1923 when her mother became ill and she had to return to Vienna. Although she left Dessauer's laboratory, Blau retained her ties. Later, she contributed a piece on photographic investigations of radioactive rays in a multiauthored volume edited by Dessauer on the boundary between physics and medicine.[100]

Getting Out of the Laboratory

82 I propose that the plan of early-twentieth-century Vienna represented the map of radium's trade and exchange. Dealing with a trafficking material such as radium, physicists were in need of interdisciplinary collaborations that became embodied in the city's roots. During this period, work on radioactivity could not be confined in the walls of the laboratory. Although research on radium's physical and chemical properties was based on the institute's laboratories, biological investigations of radium's impact on humans and other living organisms moved to the physiology laboratory in the Viertel. Moving along with them were the scientists and techniques, and always the material itself.

83 Similarly, the clinical usage and medical studies of radium were hospital-based. It was the city that provided the large numbers of cancer patients in need of radium treatments as well as the physicians who practiced radium therapy. Vienna was indeed the magnet of Europe's medical elite. Standardization of radium and the production of Austria's official radium standard by Otto Hönigschmid further placed the Radium Institute in a privileged position among the medical sites of the city and increased its esteem to the civilian authorities. Radium preparations for medical use crossed Währingerstrasse the same way that radium researchers moved over to the hospital as radium experts.

84 Respected professors such as Exner and Meyer taught the new methods of radium extraction, preparation, and handling at university amphitheaters and institutes' lecture halls. When the institute's building became inappropriate for accurate measurements, the neighboring laboratories served as alternatives whereas their libraries served as invaluable resources. Negotiations about the trade of radioactive materials and price regulations were taking place among the institute, the Academy of Sciences, and the ministries of agriculture, culture, and education.

Sites of radium consumption, such as stores selling emanators, were soon established around the institute. The interconnectedness of Vienna's medical, scientific, and intellectual elites, including the physicists, was taking place in the salons and coffee shops of the city. To the "radioactivists," the basic unit for community life had a spatial definition: the Viertel. Their sociability was centered at Exner's house and at the coffee shops of the area while their students intermingled in the university aula and on their way to various institutes on Währingerstrasse. By retaining the scientific discourse outside the laboratory, the Viennese physicists constructed a strong sense of collegiality, taking advantage of the stimulating coffee shop culture.

Despite the large number of diverse pursuits of radium researchers, Vienna's scientific center in which they located their practices was quite expedient: starting from the ring in front of the university and walking up Währingerstrasse for five minutes, one passed the Physiology Institute on the left, then the Josephinum, and across from that was the natural-science quarter. From there, it was about a ten-minute walk to the general hospital. From the ring and walking toward the center on the opposite side of the Viertel, it was about a quarter-hour's walk to reach the academy, unless one stopped at the major coffee shops of the inner city, such as the Central. **85**

Thus, the city itself played a unique and prominent part in shaping radioactivity research, filling it with both obstacles and opportunities. For the men of the field, their professional life was as motivating as their social one. Working at the Radium Institute gave them opportunities to teach at the university and to advance their careers as academics. Women, however, had a longer way to go. Although accepted as students at the city's university, they were not supposed to claim technical education until the early 1920s. Vienna's Technische Hochschule remained an obstacle for women's technical education until 1919. Moreover, their career opportunities reached a zenith with positions such as laboratory assistants but not as academic professors. The partial isolation—spatial and cultural—from the university did not necessarily mean women's exclusion from city life or other vocational institutions. For instance, the visibility that the city's confined scientific center provided to women facilitated Horovitz's assimilation into the radioactivity community. As in the case of Blau, the general hospital's radium station and Holzknecht's Röntgen Laboratory provided an opportunity to get into medical physics and stumble on related jobs. **86**

87 Rediscovering the area around the academic and medical institutes and looking out of the laboratory, reveals a great deal about the city's impact on the production of scientific knowledge. City disturbances dictated new architectural forms for scientific institutions. The grouping of physics institutes with medical establishments presented a chance for material and intellectual exchanges. Yet focusing on the city places science in the context of the local conditions and gender politics beyond the walls of the laboratory. "Places of knowledge" now became sites such as the coffeehouse, the street, the university lecture halls, and the hospital where gender relations were more likely inscribed differently from the laboratory and where knowledge emerged as a practice more obviously subjected to the local culture.

88 Although in 1920s Vienna both the local culture and the gender politics were still inscribed in its streets and buildings, they underwent major transformations. Unique political circumstances at the academic and state level fostered equally unique gender roles in the Viennese political scene and, by extension, at the Radium Institute. Red Vienna, the Viennese socialist experiment from 1919 to 1934 was not only reflected, but was to a great extent constructed within the Mediziner-Viertel.

Notes

Note 1: Mach, *Populär-wissenschaftliche Vorlesungen* (1910), 355.

Note 2: Bischof, *Frauen am Wiener Institute* (2000), 23.

Note 3: Schorske, *Fin-de-siècle Vienna* (1980), 6.

Note 4: For a detailed presentation of the relevant literature, see Beller, *Rethinking Vienna 1900* (2001).

Note 5: Anderson, *Utopian Feminism* (1992).

Note 6: For a recent collection on the urban history of science that raises similar issues and reveals the interrelation of the history of science to urban history, see Dierig, Lachmund, and Mendelsohn, *Science and the City* (2003).

Note 7: Wibiral, and Mikula, *Die Wiener Ringstrasse* (1974).

Note 8: Schorske, *Fin-de-siècle Vienna* (1980), 31.

Note 9: Wibiral and Mikula, "Heinrich von Ferstel" (1974), 45.

Note 10: On the architecture of Vienna's university see Wibiral and Mikula, *Die Wiener Ringstrasse* (1974); Plassmeyer, "Nineteenth Century Architecture" (1999).

Note 11: Schorske, *Fin-de-siècle Vienna* (1981), 40; see also Flevaris, *Universität Wien* (2001), 2; Wibiral and Mikula, "Heinrich von Ferstel" (1974), 57.

Note 12: See Plaschka, "Universität 1884" (1986).

Note 13: Schorske, *Fin-de-siècle Vienna* (1980), 47.

Note 14: Janik and Veigl *Wittgenstein in Vienna* (1998), 20.

Note 15: Maerker, *Model Experts* (2005).

Note 16: Wibiral and Mikula, "Heinrich von Ferstel" (1974), 49. As Jeffrey Johnson argues in the case of Germany between 1866 and 1914, chemistry was the first among all disciplines in the philosophical faculties to acquire its own institute. The German chemical industry, particularly coal-tar dye, and the demands from fields like pharmacy and medicine for workers with chemical training, justified the government's investment. See Johnson, "Academic Chemistry," (1985), 501. See also Meyer-Thurow, "The Industrialization of Invention" (1982). In Vienna, the situation was similar. The textile industry, the most prosperous industry in Austria, required chemists as well. See Schorske, *Fin-de-siècle Vienna* (1980), 58–59; Okey, *The Habsburg Monarchy* (2001), 229–233.

Note 17: Michl, *Geschichte des Studienfaches Chemie and der Universität Wien* (1950).

Note 18: Redtenbacher had been a student and close collaborator of Justus Liebig, director of Giessen's chemical laboratory and the central figure in the development of German organic chemistry in the early nineteenth century. For a recent account of the Giesssen model of chemistry, see Rocke, "Origins and Spread of the 'Giessen Model' in University Science" (2003). On the architecture of the Chemistry Institute, see Wibiral and Mikula, *Die Wiener Ringstrasse* (1974).

Note 19: Before Schneider accepted his position as director of the second Chemistry Laboratory, he was the director of the Chemistry Laboratory in the Josephinum, the medical school for military physicians. Schönfeld and Ipser, *Die Geschichte der Chemie an der Universität Wien und des Instituts für Anorganische Chemie* (1996).

Note 20: Brinda-Konopik, "Robert Willhelm Bunsen" (1992), 5; Michl, *Des Geschichte des Studienfaches Chemie* (1950), 61.

Note 21: Cercignani, *Ludwig Boltzmann* (1998), 6.

Note 22: Reiter, "Vienna: A Random Walk in Science" (2001), 466. In 1872, Lang was able to obtain the considerable amount of 1,210 florins and an annual donation of 1,000 florins, according to Hittner, *Geshichte des studienfaches Physik* (1949), 58.

Note 23: Karlik and Schmid, *Franz Serafin Exner* (1982), 38; Hittner, *Geshichte des studienfaches Physik* (1949), 58.

Note 24: Hittner, *Geshichte des studienfaches Physik* (1949), 58–59.

Note 25: Wibiral and Mikula, "Heinrich von Ferstel" (1974), 61.

Note 26: Karlik and Schmid, *Franz Serafin Exner* (1982), 33; For the establishment of the Institute for Physical Chemistry, the government offered the generous endowment of 6,400 florins and an annual donation of 800 florins in Hittner, *Geshichte des studienfaches Physik* (1949), 60.

Note 27: The *Arbeiterzeitung* was among the newspapers that openly supported the Social Democrats; see Rabinbach, *The Crisis of Austrian Socialism* (1983), 27. Karl Przibram was the one who recalled the incident; see Przibram, "Errinerungen" (1959), 1. See also Benndorf, "Gedenkrede auf Franz Serafin Exner" (1937), Nachlass Exner, AÖAW; Sime, *Lise Meitner* (1996), 11.

Note 28: For the history of Vienna's Physics Institutes, see Hittner, *Geschichte des Studienfaches Physik* (1949); Lintner and Schmid, "Das II. Physikalisches Institut der Universität Wien" (1965); Reiter, "Vienna: A Random Walk in Science" (2001).

Note 29: Cercignani, *Ludwig Boltzmann,* (1998), 30.

Note 30: In 1894, Boltzmann succeeded Stefan as director of the *Physikalisches Institut*. In 1900, dissatisfied with political and professional conditions in Austria, he accepted an appointment as Professor of Theoretical Physics in Leipzig. He returned to Vienna in 1902 (Hittner, *Geshichte des studienfaches Physik* (1949), 64–65; Cercignani, *Ludwig Boltzmann* (1998), 28–29).

Note 31: Reiter, "Vienna: A Random Walk in Science" (2001), 471. Between 1894 and 1900, Boltzmann, as director of the *Physikalisches Institut*, was also responsible for conducting laboratory courses. Because of the load of his own research, he asked to be excused from the above duty. Exner was the one who had to take over the responsibility. In addition to his own laboratory courses in physics, Exner was obliged to direct Boltzmann's as well. The odd situation ended when Boltzmann left Vienna, accepting the position in Leipzig. On his return in 1902, the rearrangement of the physics laboratories revealed the old tension between Exner and Boltzmann, creating the only exceptional case of a conflict between colleagues at Türkenstrasse; see Cercignani, *Ludwig Boltzmann* (1998), 28–30.

Note 32: Reiter, "Vienna: A Random Walk in Science" (2001), 471; Lintner and Schmid, "Das II. Physikalisches Institut" (1965), 379; Karlik and Schmid, *Franz Serafin Exner* (1982), 65.

Note 33: Karlik and Schmid, *Franz Serafin Exner* (1982), 63. Exner's close friendship with Röntgen went back to the time that he spent the third year of his studies in Zurich under the physicist August Kundt and later in Strasburg where both worked as *Assistentent* at the university.

Note 34: Karlik and Schmid, *Franz Serafin Exner* (1982), 63.

Note 35: Benndorf, "Worte der Erinnerung an Franz Exner" (1926), Nachlass Exner, AÖAW.

Note 36: Przibram, "Errinerungen" (1959), 3.

Note 37: Benndorf, "Worte der Erinnerung an Franz Exner" (1926), Nachlass Exner, AÖAW.

Note 38: Karlik and Schmid, *Franz Serafin Exner* (1982).

Note 39: Benndorf, "Worte der Erinnerung an Franz Exner" (1926), Nachlass Exner, AÖAW.

Note 40: Bischof, *Frauen am Wiener Institut* (2000), 23.

Note 41: Coen, *A Scientific Dynasty* (2004), 52.

Note 42: Karlik and Schmid, *Franz Serafin Exner* (1982), 52. See also Coen, *A Scientific Dynasty* (2004).

Note 43: Barea, *Vienna* (1966), 254.

Note 44: Anderson, *Utopian Feminism* (1992), 26, 29.

Note 45: Bandhauer-Schöffman, "Frauenbewegung und Studentinnen" (1990), 50–54.

Note 46: Anderson, *Utopian Feminism* (1992), 253.

Note 47: Anderson, *Utopian Feminism* (1992), 11.

Note 48: Anderson, *Utopian Feminism* (1992), 113; on Friedrich Jodl see also Korotin, "Auf Eisigen Firnen" (1997), 292.

Note 49: Based on her unpublished data and research, Brigitte Bischof argues that the participation of women in physics at the University of Vienna was much higher than, for example, that at the University of Graz. The support of the physics community made the case of Vienna unique within Austria. (personal communication with Bischof).

Note 50: Bischof, *Frauen am Wiener Institut* (2000), 23.

Note 51: Sime, *Lise Meitner* (1996), 14.

Note 52: Cercignani, *Ludwig Boltzmann* (1998), 11.

Note 53: Sime, *Lise Meitner* (1996), 9.

Note 54: Meitner, *Looking Back* (1964), 2.

Note 55: Heindl, "Zur Entwicklung des Frauenstudiums in Österreich" (1990), 17.

Note 56: Tuma, "Die Österreichischen Studentinnen der Universität Wien" (1990), 87.

Note 57: Andraschko, "Elise Richter" (1990).

Note 58: Anderson, *Utopian Feminism* (1992), 31. Many of the women who later worked at the Institute for Radium Research attended the *Obergymnasium*.

Note 59: Bandhauer-Schöffman, "Frauenbewegung und Studentinnen" (1990), 66. The amount of 150 florins was equivalent to the annual tuition to the *Gymansiale Mädchenschule.* See also Anderson, *Utopian Feminism* (1992), 31.

Note 60: The figures in this table are based on Renate Tuma's work on Austrian women students in the University of Vienna; Tuma, "Die Österreichischen Studentinnen der Universität Wien" (1990), 80. See also Plech, "Das frauenstudium an den philosochischen Fakultäten" (1968).

Note 61: This chart includes both Austrian and international students.

Note 62: Tuma, "Die Österreichischen Studentinnen der Universität Wien" (1990), 81.

Note 63: Anderson, *Utopian Feminism* (1992), 31–32.

Note 64: Anderson, *Utopian Feminism* (1992), 90–91.

Note 65: Tuma, "Die Oessterreichischen Studentinnen der Universitaet Wien" (1990), 87.

Note 66: Bischof, "Olga Steindler (1879–1933)" (2001).

Note 67: Przibram, "Errinerungen" (1959), 3.

Note 68: Sime, *Lise Meitner* (1996), 12.

Note 69: Tuma, "Die Osterreichischen Studentinnen" (1990), 87. The total in the table refers to the actual number of women enrolled at the philosophical faculty of the University of Vienna. Those were able to attend several courses in different fields. This is why the total does not match the numbers given by field.

Note 70: Stewart, "Other Centers of Calculation" (1999); Trevor, "Public and Private Science" (2002).

Note 71: Golinksi, "Conversations on Chemistry" (2002).

Note 72: Crane, *The Club of Honest Whigs* (1966).

Note 73: Heise, *Kaffe und Kaffeehaus* (2002); Schorske, *Fin-de-siècle Vienna* (1980), xxvii.

Note 74: Robinson and Keen, "Café kultur: the Coffeehouses of Vienna" (1996).

Note 75: Janik and Toulmin, *Wittgenstein's Vienna* (1973), 34.

Note 76: Przibram, "Errinerungen an ein altes physikalisches Institut" (1959), 1.

Note 77: The percentage of 16.7 refers to the number of female authors from 1910 to 1919. There were actually eight women: Eleonore Albrecht, Marietta Blau, Friderike Friedmann, Hilda Fonovits, Bertha Heiman, Stephanie Horovitz, Grete Richter, and Helene Souczek. The proportion of articles that were published or coauthored by women is up to 8.6 percent. The first volume of the *Mitteilungen* includes articles of Ernest Rutherford, Bertram Boltwood, and William Ramsay that I did not take into account for calculating the above percentages.

Note 78: Herzfeld, "Über die Schwankungen der Reichweite" (1912).

Note 79: Friedmann, "Experimentelle Bestimmung" (1913).

Note 80: Mikoletzky, Georgeacopol-Winischhofer, and Pohl, "''Dem Zuge der Zeit entsprechend . . . '" (1997). Friedmann remained at the Radium Institute until 1919. On Kara-Michailova see Sretenova, "Elizabeta Karamichailova" (2003).

Note 81: Badash, "The Suicidal Success of Radiochemistry" (1979), 250.

Note 82: Zintl, "Otto Hönigschmid zum 60 Geburtstag" (1938).

Note 83: Sabine, "Lise Meitner an Otto Hahn" (1992), 149. The original letter from Meitner to Hönigschmid, January 26, 1914, is deposited at the Churchill College Archives, Cambridge University, MTNR 5/78.

Note 84: Rayner-Canham, M. and G. "Stefanie Horovitz" (1997), 194.

Note 85: Rayner-Canham, M. and G. "Stefanie Horovitz" (1997), 194.

Note 86: Badash, "The Suicidal Success of Radiochemistry" (1979), 252. Hönigschmid and Horovitz, "Über das Atomgewicht des ''Uranbleis''" (1914); Hönigschmid and Horovitz, "Sur le poids atomique du plomb de la pechplende" (1914); Hönigschmid and Horovitz, "Über des Atomgewichtes des ''Uranbleis''" (1914); Hönigschmid and Horovitz, "Über des Atomgewichtes des ''Uranbleis II" (1915); Hönigschmid and Horovitz, "Zur Kenntnis des Atomgewichtes" (1915); Hönigschmid and Horovitz, "Revision des Atomgewichtes des Thoriums," (1915); Hönigschmid and Horovitz, "Zur kenntnis des Atomgewichtes des Ioniums" (1916).

Note 87: Rayner-Canham, M. and G. "Stefanie Horovitz, Ellen Gleditsch" (2000), 104. Rayner-Canham, M. and G. "Stefanie Horovitz: Crucial Role in the Discovery of Isotopes" (1997), 192.

Note 88: Badash, "The Suicidal Success of Radiochemistry" (1979), 252.

Note 89: Rayner-Canham, M., and G. Rayner-Canham, "Stefanie Horovitz" (1997), 194.

Note 90: Hönigschmidt to Meitner, June 24, 1914, Churchill College Archives, Cambridge University, MTNR 5/78 (my emphasis).

Note 91: Soddy, Frederick. 1922. "The Origins of the Conceptions of Isotopes" Nobel Lecture, December 12, 1922, http://nobelprize.org/nobel_prizes/chemistry/laureates/1921/soddy-lecture.html.

Note 92: Fajans to Rona, August 31, 1963, BHL; Rayner-Canham, M. and G., "Stefanie Horovitz" (1997), 195.

Note 93: Marietta Blau, Curriculum Vitae, July 4, 1918, Rigorosenakt 4557, AUW.

Note 94: Blau, "Absorption divergenter Gamma-Strahlung" (1918).

Note 95: Gerward and Rassat, "Le decouverte des rayons gamma" (2000).

Note 96: Marietta Blau, Curriculum Vitae, 1941, GDSCA.

Note 97: Meyer to Riehl, June 7, 1912, AÖAW. Meyer, "Das erste Jahrzehnt" (1920), 12; Meyer, "Die Vorgeschichte" (1950), 20; Protokoll Z 8167, November 30, 1911, AÖAW.

Note 98: Marietta Blau, Curriculum Vitae, 1941, GDSCA; Galison, "Marietta Blau" (1997), 42.

Note 99: Beyler, "Imagine a Cube" (1997), 39–46.

Note 100: Blau, "Über photographische Untersuchungen" (1931).