

# The Scientific Community of Chemists and Physics in the Nineteenth-Century Habsburg Monarchy

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In 1838 the famous chemist Justus von Liebig published his treatise, "The Condition of Chemistry in Austria"<sup>(1)</sup> (Der Zustand der Chemie in Österreich) in his renowned journal, The Annals of Chemistry and Pharmacy (Annalen der Chemie und Pharmazie). After analyzing and criticizing contemporary Austrian chemists, he concluded that chemistry as conducted in Austria could not be termed scientific.

When, some twenty years later, Ernst Mach began studying physics at the University of Vienna, he told one of his professors that he would like to become a scientist and enter a university career. The professor advised Mach to chose another field because physics as a science was finished. With few problems left to be solved, physics was simply not worth studying.<sup>(2)</sup>

Despite this advice, Ernst Mach pursued his dream and today his name symbolizes the unit used to calculate the speed of sound. Many other Austrian scientists who lived and worked in the nineteenth century became famous in the world of scholarship, including the physicists Ludwig Boltzmann, Josef Loschmidt, and Ludwig Auer von Welsbach, and the chemists Heinrich Hlasiwetz, Zdenko Hans Skraup and Fritz Pregl.

What were the reasons behind the progression of Austrian science from a mediocre discipline in the middle of the nineteenth century to a field characterized by a high standard of achievement at the beginning of the twentieth? What were the forces and circumstances that influenced the life and the work of Austrian chemists and physicists in this same period? In this paper I will focus on the community of chemical and physical scientists in Austria from the middle of the nineteenth century to World War I in order to reveal some of the conditions responsible for this evolution.

In the second half of the nineteenth century science in the Habsburg Monarchy was the province of the educated middle class, the so-called "Bildungsbürgertum."<sup>(3)</sup> The majority of scholars were not wealthy and required to live from their salaries.<sup>(4)</sup> Only a few came from the affluent middle classes ("Besitzbürgertum") and the nobility, although some of the most renowned middle-class scientists were subsequently made peers of the realm. Only rarely did a gifted child of peasant or working-class origin succeed in becoming a member of the world of learning, as the recipient of a state scholarship.

The members of the Austrian world of scientific scholarship were largely employees of state institutions, primarily universities and colleges, but also libraries. From the 1880s on they could also work as managers of factories or in small industrial research laboratories and later in newly-created special research institutes (such as the Radium Institute in Vienna). As a group they cut themselves off from the capitalist bourgeoisie, preferring the company of the cadre of higher civil servants, including physicians, lawyers, and army officers. In short, most university professors, scholars and scientists were members of the educated middle-classes and most hailed from there as well. They enjoyed high social prestige (higher than any other middle-class group) and were generally not involved in politics, although they demonstrated political preferences, voting liberal in the middle of the century and nationalist at the turn of the century. They were of the opinion that they themselves were the most or perhaps even the only progressive segment of Austrian society.

In comparison with earlier eras nineteenth-century science greatly increased in complexity. It was no longer feasible to do research as a hobby or a way of passing time, as some interested aristocrats had done before the eighteenth century. Now the members of the world of scholarship had to work hard. As students they had to digest increasingly-voluminous textbooks<sup>(5)</sup> and memorize numerous facts and formulas. As scientists they had to sequester themselves in laboratories.<sup>(6)</sup> Even in the first half of the century scientists were required to work full days and according to a stringent schedule. A famous scholar of the period once said: "Scientific research is work, hard work, and he who does not like to work should refrain from it."<sup>(7)</sup> Such a regime offered little enticement to nobles accustomed to a more leisurely pace, but was a common and significant feature of the peasantry, and working and middle classes.

Very little research was conducted outside of universities and technical colleges, as costs prohibited private laboratories. In addition, throughout the course of the nineteenth century scientific research became so specialized that it became impossible to do research in more than one field. When the German physicist Julius Robert Mayer published his

famous treatise on the maintenance of energy in the early 1840s, he was already an exception. Scientists in this period required increased funding and additional laboratories, something only the state could afford. Thus, the history of the Austrian scientific community in this era is largely the history of nineteenth-century universities and the prevailing system of higher education.

In the middle of the nineteenth century the Austrian educational system was entirely reorganized. The so-called Thun reform,<sup>(8)</sup> named after the minister for educational affairs, was potentially the most important change in the history of Austrian university education, if not of the entire educational system. This reform established much the same educational system as that already in use in most German countries. It was based on the educational principles of Wilhelm von Humboldt, who instituted this system in 1810 at the newly-founded University of Berlin.

During the Revolution of 1848, scientific freedom and academic liberty were proclaimed for the first time.<sup>(9)</sup> Although the political system reverted to neoabsolutism in the 1850s following a brief constitutional period, the crown made no attempt to curb these scholastic liberties and was particularly careful to respect academic freedom of speech. When in the 1850s the young chemist and university teacher Anton Schroetter von Kristelli openly criticized the young emperor Francis Josef, an informer reported it to the Interior Ministry, a customary occurrence in the pre-Revolutionary era. The informer was told that the Ministry no longer required information of this nature and added that the old way of doing things was over.<sup>(10)</sup>

At the high school level the reform of 1848 established a new grading system of eight grades and the high school diploma. This diploma became the decisive requirement for admission to university. Educated in similarly-organized Germany, Albert Einstein called the final exam required for this diploma the most difficult exam he ever took.

After 1848 universities remained divided among four schools or faculties: theology, law, medicine and the so-called philosophical faculty. The chairs and laboratories of botany, physics and chemistry were transferred from the medical faculty to the totally-revamped philosophical faculty. While the latter had primarily served as a training ground for more-advanced theological, juridical and medical studies prior to 1848, following the Revolution the philosophical faculty was raised to the level of the other schools. As such it could teach "all the university-taught subjects that were of no use in practical life," as a contemporary document put it.<sup>(11)</sup> These "useless" fields included the hard sciences, the humanities, and, later, the social sciences. Philosophy, languages, history, geography, mathematics, physics, chemistry, botany, geology, and mineralogy were all part of the philosophical faculty. In the early twentieth century Oswald Spranger termed this school the "universe of scholarship."

It is surprising to hear fields of science being designated of no practical use, especially since they all had minor practical applications even in the middle of the nineteenth century. However, applied science was not the province of the university but fell to the technical colleges, founded in the first and the second decades of the nineteenth century.

In order to understand the necessity of these mid-century reforms we must briefly examine educational conditions in the first half of the century. When Emperor Francis I declared at the Congress of Laibach in 1820 that he had no use for scholars because most did meaningless work and were frequently nonconformist, he did so largely because of his fear of revolution. He died before his judgement was confirmed by the Revolution of 1848, whose ideas attracted the sympathy of many younger scientists and scholars and was carried out largely by students.

Apart from his public dislike of scholars and their theoretical approach, Francis privately appreciated certain fields because of their utility in enhancing the economy and promoting national wealth. He therefore supported technical and scientific research measures among the nobility to the extent that they acted as entrepreneurs. The nobles of Bohemia had started providing technical learning in the late-eighteenth century. Francis expanded this effort by helping to establish technical colleges in Prague,<sup>(12)</sup> Graz<sup>(13)</sup> Vienna,<sup>(14)</sup> and later in Lemberg.

All of these technical colleges were well-endowed and equipped. When the famous chemist and professor at the University of Göttingen Friedrich Woehler visited Vienna in the early 1840s, he wrote his Swedish friend Joens Jacob Berzelius about the laudable features of the chemical laboratory of the Viennese technical college, only to finish his description: "But nobody is working there!"<sup>(15)</sup>

He was right. There were only a few chemists in the Habsburg Monarchy then doing research in the field of analytical and inorganic chemistry, and none in organic chemistry, despite the fact that the first substantial steps in organic chemistry were already underway in Germany, France and Sweden. Friedrich Woehler had synthetically produced the first organic substance in 1831, while Justus Liebig and the French chemist Auguste Dumas had developed methods of organic analysis.

Owing to the negative dogma surrounding the practical utility of chemical research (an idea that had prevailed in Austria since the early Enlightenment) chemistry fell further behind physics during the first half of the nineteenth century. Both the chairs for chemistry and physics had been created in the middle of the eighteenth century, when steps were taken to wrest Austrian higher learning from the influence of the Jesuits. Both sciences were intended to impart a higher level of education to pharmacists and physicians, which accounted for their original position on the medical faculty. Well-trained physicians and pharmacists were viewed as an important constitutive factor in an improved public health system, which in turn could support an increased population and thus a more powerful state. But it took some time until chairs for physics and chemistry at all in the 80s of the 18th century new-founded medical schools were established. It was only in the first half of the nineteenth century that the so-called auxiliary sciences of medicine, (physics, chemistry and botany) became obligatory parts of the medical curriculum in the Monarchy.<sup>(16)</sup>

Chairs in physics were also established as part of the preparatory philosophical faculty, but only those parts of the discipline regarded of use to future priests, physicians and

lawyers were taught. This was rudimentary science, designed to give these professionals scientific explanations for suspect phenomena and thereby prevent the spread of superstition.

In sum, both Justus Liebig and Friedrich Woehler were right when they criticized Austrian science, especially chemistry.

The main problem facing Austrian chemistry in the first half of the nineteenth century was that students primarily received only theoretical training, not practical hands-on training in laboratories.<sup>(17)</sup> Throughout the course of their studies they were required to work in the lab only twice. The same held true for physics, as the two sciences were taught together rather than exclusively; since the chemical industry did not yet exist, there were no jobs for a trained chemist alone. In addition, those most interested in chemistry, pharmacy students, had generally received practical training as apprentices prior to entering university. Thus, the latter was seen as an opportunity to acquire theoretical knowledge.<sup>(18)</sup>

Interestingly, toward the middle of the nineteenth century, a new mode of chemical training was created by Justus Liebig, himself trained as a pharmacist. When he announced his intention to go to Paris as a post-graduate student in order to become a chemist, nobody really knew what kind of profession he intended to enter. He eventually became famous for his textbooks and created the new periodical, "The Annals of Chemistry and Pharmacy", later named simply The Annals of Chemistry.

Liebig was convinced that chemists should not only know everything about chemical theory, but they should be able to merge theory and practice in chemistry in order to be able to anticipate potential problems. The best way to prepare students for research was under the tutelage of a master scientist in the laboratory. As a professor at the University of Giessen in the 1820s, Liebig began training students in this manner. His methods proved to be a significant step in the evolution of chemistry.

It took some time for this revolutionary curriculum to be adopted in Austria, although it was realized prior to the Thun reform of 1848 through the intercession of the imperial Chancellor, Metternich. That the reactionary figure of Metternich played a crucial role in the development of Austrian chemistry is more than a little ironic. Still, Metternich considered his particular brand of policy-making similar to science in its precision and use of reason, and he generally believed that in order to be successful one must have a command of all the facts.<sup>(19)</sup> He liked to communicate with scientists and to demonstrate how well-informed he was about contemporary science. At the same time he desired to be instructed about new results and theories.

In the late 1830s the physicists Karl von Reichenbach and Albert von Ettingshausen called Metternich's attention to chemistry and the need for reform in the chemical curriculum. They were prompted to do so by Bohemian entrepreneurs seeking new innovations for their production processes. As most of these entrepreneurs were also nobles, they too had access to and increasingly petitioned Metternich to intercede in the

reorganization of chemical training. Both entrepreneurs and scientists understood the potential impact of chemical science on economic development and conveyed its import to the Chancellor. It was this rationale that spurred Metternich to attempt to appoint Justus Liebig to the University of Vienna.

He invited Liebig to Vienna in 1840, offering him a lucratively-endowed chair in chemistry and the most modern of facilities. Liebig returned to Giessen, but negotiations proceeded. Liebig eventually declined the position although the exact reasons for his refusal are not known. He undoubtedly received a salary increase at Giessen, but why did he negotiate so long?

In response, the Austrian government decided that rather than offering the chair to another top-notch chemist they would sponsor scholarships for students to study with Liebig in Giessen. Among the first young Austrian chemists who went to Giessen in the early 1840s were Josef Redtenbacher, Friedrich Rochleder, Theodor Wertheim and Anton Schroetter von Kristelli.

Redtenbacher was still in Giessen when he was appointed professor of chemistry at Prague University. With his appointment a second opportunity was opened for training young Austrian chemists in the modern way. From 1841 to 1852, (when Liebig moved to Munich and no longer trained young scientists) every Austrian chemist embarking on a university career studied either in Giessen or in Prague.

The reform of the educational system in 1848 completed the overhaul of the chemical faculty and curriculum already underway at some Austrian universities and technical colleges. The new training system was established at the technical college in Graz in the early 1840s, at the technical college in Lemberg in 1845, at the technical college in Vienna in 1846, and at the universities of Vienna, Graz and Innsbruck between 1848 and 1850. After 1848 the government forced elder chemists into retirement, and those trained by Liebig or Redtenbacher succeeded to the chairs. Thus, a young generation of chemists (average age 30) henceforth headed research and teaching in Austria.

Redtenbacher was appointed to a professorship in Vienna in 1849 and was succeeded in Prague by Friedrich Rochleder. At the University of Graz Franz Hruschauer was succeeded by Theodor Wertheim, who had in turn been teaching at both Vienna and Budapest. In Wertheim's stead Carl von Than was appointed to the chair in Budapest. Von Than had been trained by Redtenbacher in Vienna and by Bunsen in Heidelberg, and himself trained most Hungarian chemists from the early 1860s. Heinrich Hlasiwetz began teaching at Innsbruck in 1850 and was later appointed to Vienna.<sup>(20)</sup>

In tandem with these staff changes in the post-Revolutionary era came substantial changes in the curriculum: instead of inorganic and analytical chemistry, organic chemistry became the dominant field of investigation. Despite the local cadre of modern-trained professors Austrian chemistry students continued to study abroad for some time. A few went to Paris, but most continued to go to Germany, where they studied under Robert Wilhelm Bunsen in Heidelberg, August Wilhelm Hofmann in Berlin or August

Friedrich Kekule in Bonn. Still, the increasing number of students and chemists doing research within Austria prompted the Austrian government to build new chemistry labs in the 1860s.

The first of these state-of-the-art facilities was built in Vienna, followed by Graz, Prague and Innsbruck in the 1870s. Some were said to be the best-equipped of all new European laboratories at the time.

In the 1860s the importance of chemistry became obvious to everyone.<sup>(21)</sup> In Germany the first small chemical factories were created to produce coal tar dyes. Some of their names are still well known: BASF, Bayer, Hoechst. A few years later similar factories were built in Austria, but unable to expand, most went bankrupt in the early 1870s during the Great Depression.

In short, it took about two decades after Justus Liebig's critique of Austrian chemistry for the Austrians to catch up to technical standards of Germany and France. But by the end of the 1850s Austrian chemistry had become internationally renown. Austrian chemists published their treatises in periodicals such as Liebig's Annals and the Journal for Practical Chemistry and in the national periodical of the Austrian Academy of Sciences (Akademie der Wissenschaften). In the late 1870s, another national periodical, Chemistry Monthly (Monatshefte der Chemie) was founded.

Although this first generation of modern Austrian chemists published the results of many practical investigations, they did not participate in the theoretical discussions of the 1840s and 1850s about organic chemistry (how organic substances were compounded, Gebhardt's theory of types, and so on). These discussions were all but over by the time they were experienced enough to take part. On the other hand, important branches of chemistry were established in Austria during this period. While Heinrich Hlasiwetz began the systematic investigation of the chemistry of plants, Florian Heller took the first steps in the field of clinical chemistry, applying chemistry to medicine in the period of the second Vienna medical school.<sup>(22)</sup>

While this radical change in the staffing and agenda of chemistry was underway, little of a similar nature happened in physics. Of course, students of physics studied abroad as well, but the state did not award as great a number of scholarships to young physicists as it did to young chemists. Changes in physics took place only from the 1860s on, when the government started to build new physics labs and to create new chairs for physics specializing in theoretical, mathematical and experimental physics. This provided an ideal period for young physicists to forge ahead in the academic hierarchy. One of these young professors was Ludwig Boltzmann.

The subsequent two decades (from the middle of the 1870s to the early 1890s) were a period of slow expansion for universities and chemical and physics laboratories. Then, in the last decade of the nineteenth century, a new era of expansion began. Universities faced increased enrollments. At Vienna the student population increased from about 1200 at the middle of the century to nearly 7000 at the end of the century, while Graz

experienced a jump from about 400 to 1500 in the same time period. In the late 1890s women were generally allowed to study at philosophical and medical faculties, and university professors began to inform the lay public about the main problems of their field and the latest discoveries. Public interest in turn stimulated more research and discovery (as in the celebrated case of x-rays), and many physicists gave lectures within the framework of this so-called university extension movement.

A new period in the field of chemistry also began at this time. In the summer of 1887 a postgraduate student came to Graz to hear Ludwig Boltzmann's lectures. His name was Svante Arrhenius. He had left Sweden after his controversial thesis on the what became his famous theory of dissociation had finally been accepted. After some wrangling on the part of his professors, who generally misunderstood his theory, Arrhenius set out on a tour of European universities.<sup>(23)</sup>

During the same summer term another student happened to be in Graz, Walther Nernst. Both Arrhenius and Nernst seemed to have enjoyed their sojourn there, for Boltzmann gave no lectures during this term, and they quickly made friends with each other. In July a young German professor by the name of Wilhelm Ostwald came to Graz to visit Arrhenius and to tell him that he just had been appointed professor of physical chemistry at the University of Leipzig. When Ostwald asked Arrhenius if he knew a young gifted scientist who could serve as his assistant in Leipzig, Arrhenius named Walter Nernst.

The discoveries of Svante Arrhneius, Jacobus Henricus van't Hoff and Wilhelm Ostwald in the 1880s greatly impacted the discipline of physical chemistry. Austrian universities began to institutionalize physical chemistry in the early 1890s, although it took some years for the first chair to be created. Svante Arrhenius was offered a professorship at Graz in this period but failed to take it owing to a simultaneous offer from the University of Stockholm. He went on to become a member of the Swedish Academy and participated in the debate over Alfred Nobel's foundation in the early twentieth century.

While in the earlier part of the century physics was represented at each Austrian university by at least two professors (one for theoretical and one for experimental physics) there was generally only one full professor of chemistry per faculty because chemical research focused on organic chemistry alone. From the 1890s on, chairs in both physical and inorganic chemistry were increasingly created.<sup>(24)</sup> Nevertheless, this period was also characterized by increased study abroad for Austrian students specializing in the field of physical chemistry. Such students customarily went to Stockholm and to Leipzig or Göttingen, but rarely to Paris.

International exchange increased among credentialed scientists as well. For the first time these contacts extended beyond the borders of Europe. Ludwig Boltzmann, for instance, traveled twice to America, and Australian chemists visited the laboratories of provincial universities of the Habsburg Monarchy in the first decade of the twentieth century. This international cooperation was ruptured by the onset of World War I, and it took some time to re-establish in the wake of the conflict. French scientists were particularly bitter toward their Austrian colleagues, blaming them for the outbreak of the war.<sup>(25)</sup>



Prior to the war a higher number of foreign scholars, primarily Germans, were appointed to Austrian chairs than ever before. Although they maintained contacts with scholars in many countries, Austrian scientists established their closest connections with the German scientific community.<sup>(26)</sup> This was due not only to the impressive progress of German science and education in the second half of the century,<sup>(27)</sup> or the similar organization of German and Austrian university systems after 1848, but was based on a previous relationship between Austrian and German scientists which had originated in the 1830s, when the era of scientific conferences and journals first came into existence. An important aspect of this regime were the annual meetings of German scientists and physicians ("Versammlungen deutscher Naturforscher und Ärzte"), begun by Lorenz Oken. The guiding spirit of such groups was to promote German national science. In the wake of the Congress of Vienna disappointment ran high over the failure to establish a united German empire. Such meetings were seen as a vehicle for a union of ethnic German scientists, and a symbolic union of the German mind. Austrians took part in these meetings, for, as Heinrich Lutz put it, the German-speaking countries were Austrian before the war of 1866 and only Prussian afterwards. As though to punctuate the transition, the annual conference was canceled during the Austro-Prussian War of 1866.

These meetings were held in both Austrian and German cities. In 1832 the Austrian astronomer Littrow sang the praises of German national union in Vienna. Prague hosted the conference in 1837 and Graz in 1843. In the second half of the century all three of these cities were again host sites, along with Innsbruck, Meran and Karlsbad.<sup>(28)</sup>

Imperial Austrian chemists and physicists attended these meetings promoting German national science as a matter of course, despite the fact that they lived in an ethnically-mixed state and were themselves of ethnically-mixed stock. In many cases Jewish, Slavic or Hungarian scientists were obliged to openly declare their nationality. The chemist Zdenko Hans Skraup, for instance, the son of a Czech father and a German mother, decided to declare himself German, while his uncle became a leading Czech nationalist. Ethnic conflicts among Austrian physicists and chemists became especially acute when a successor for an open chair was to be nominated.

Regardless of their nationality or mother tongue Habsburg chemists and physicists were members of the German-speaking scientific community. To what extent they were integrated within this community remains open to debate. Some undoubtedly felt German, and most remained loyal to the Habsburg crown. When the monarchy dissolved in 1918, however, most university professors were relieved that the period of intense national quarreling was at an end, and most expected that conditions would be much better within the successor states. German-Austrian scientists regarded the union of the former Monarchy's German-speaking part ("Deutsch-Österreich") with Germany as the logical outcome of the collapse. Indeed, at war's end no other segment of the Austrian population supported Austrian political union with Germany as unanimously as Austrian academics. One result of this was that during the inter-war period a higher percentage of Austrian university professors sympathized with National-Socialism than their German counterparts.

But let's return to the situation in 1918 and the preference of most scholars for a national state. Had academic life in imperial Austria really been so bad for ethnic minorities? To answer this we must examine the ethnic distribution among the chairs of Habsburg universities. It should be noted that having a university had become a key symbol of a nationality's identity since the Czech nationalist movement had attained the partition of Prague University into separate Czech and German institutions in 1882. The appointment of a professor to a chair could therefore be a highly delicate matter of domestic policy.

Although universities were supported by the state they were for the most part autonomous. This was not entirely the case when it came to the appointment of new professors, however. The process was initiated when the university proposed a list of names, (generally of three scholars, sometimes more, but rarely only one) from which the Ministry of Education then selected the new appointee. Thus, the state exercised at least an indirect influence on the ethnic distribution of scientists within universities.

In the Hungarian part of the Empire Magyars were appointed to the Universities of Budapest and Cluj, while both Magyars and Croats were seated at the University of Zagreb. At Cracow University courses were conducted in Polish, and the staff was therefore largely comprised of ethnic Poles. As previously mentioned, Charles University in Prague was divided in two in 1882, with both German and Czech faculties and curricula.

Although lectures in Italian were given at the University of Innsbruck, an Italian scholar was rarely proposed for a chair by the university. When at the turn of the century the Austrian government tried to establish an Italian university in Trieste, the University of Innsbruck strenuously protested, and German members of Parliament successfully protracted the passage of the bill until 1914.

Although there were some professors of south Slavic stock at Graz, Innsbruck, and Vienna they always spoke German and were cautioned by their German colleagues to refrain from any kind of nationalistic activity. Jews were rarely appointed to chairs in Graz or Innsbruck, but did find positions in Vienna, Prague, Lemberg, and Czernowitz.

As to precise numbers, of the approximately 200 Austrian chemists working at universities in 1900 were about 12 percent were Jews. At universities where German was the language of instruction South Slavs comprised little more than ten percent of the faculty, with few Czechs, and no Slovaks or Poles.

Thus, the generalized character of nationalistic strife within the Monarchy made it possible for a surprisingly high number of Jewish intellectuals to ascend the academic ladder. The percentage of Jewish faculty members was predictably highest at the University of Vienna, the largest university in both the Monarchy and the German-speaking world during the second half of the nineteenth century.

Jews working in the field of chemistry also greatly outnumbered those doing research and teaching in physics. One obvious reason for this discrepancy is that by this time there

were simply more jobs for chemists than for physicists. I estimate the total number of chemists working in Austrian factories at about 700 in 1900. Still, it is a small number in comparison with Germany, whose imperial occupational census of 1895 revealed approximately 3000 chemists working in this burgeoning sector. By 1907 this number had nearly doubled (c. 5.800). There were some twenty "big firms" in Germany in 1912, each employing at least twenty chemists. The three giant coal tar dye firms (BASF, Bayer, Hoechst) together employed about one-tenth of all the chemists in the country (about 870 in 1912). So the group of chemists working in the biggest and most important chemical industry of the world was rather a small one.<sup>(29)</sup>

Another reason for the comparatively high number of Jews working in chemistry was that chemistry was the most successful and progressive science of the late nineteenth century. The impact of chemistry on everyday life had become evident. After Emil Fischer of Berlin had discovered the structure of protein at the end of the nineteenth century, the French chemist Berthollet pronounced that chemistry had solved all the major problems of the century, and declared that it was just a matter of time until it would be possible to synthesize all substances. He concluded that at the end of the twentieth century agriculture would be obsolete, for nutritional provision would no longer fall within the purview of farmers, but of chemists.

Moreover, at the turn of the century not only chemists were of the opinion that chemistry would decide which country would win the next war. Today we know the full implications of such truths and can solemnly reflect upon the importance to the German army of such inventions as Fritz Haber's<sup>(30)</sup> synthesis of ammonia. It is no wonder that chemistry was seen as a matter of highest national importance, even then.

Another important factor influencing science in this period was a shortage of funding. Between 1875 and 1914 Austrian university expenses tripled with the highest increase occurring in the last eight years prior to the outbreak of World War I. Most of this was spurred by increased spending on technical colleges, where between 1890 and 1905 average enrollment tripled (Vienna, Graz) and even quadrupled (Prague, Brünn and Lemberg). The latter figure reflected the influx of Slav students into these institutions, and also represented the disproportionately higher spending of the national government on universities and technical colleges in non-German-speaking areas, compared with a stagnating level of funding for German-speaking regions. The result was degraded facilities in the latter areas. At the University of Vienna, for instance, laboratories were small and out-of-date by the turn of the century.

In addition, many German-speaking scientists, alienated by this erosion, sought positions in Germany, where their colleague's salaries were one-third higher, the institutes well-equipped, and the chemical industry provided a consistent source of employment. (A few Austrian chemists were even paid by German chemical firms to present the results of their investigations prior to publishing them in periodicals.) Austrian students also envied their German counterparts, who could find jobs much more readily within the large German chemical establishment.

In 1893 a book on German universities was published on the occasion of the World Exhibition in Chicago.<sup>(31)</sup> The editor commented upon the rise, and, as he put it, "the world wide-importance" of German science and technology during the previous decades. He directly tied this achievement to the structure of German universities, a structure shared by all German-speaking nations. In his view the autonomy of universities supported a positive system of competition for appointments and each Ministry of Education strove to appoint the very best professors. In turn, the best students were drawn by the talents of these expert professionals.

In fact, this was a rather idealistic view of the system. Most German chemistry majors, especially those intending to work in the chemical industry, were primarily concerned with completing their theses in the shortest possible time. And most professors were interested in teaching at universities where they were paid the highest salaries. This mindset was so common that a contemporary German scholar was led to observe that in the temple of science most priests rallied around the offertory box, rather than the altar!

To conclude, I would like to recapitulate the major influences on the progress of Austrian chemistry and physics from the middle of the nineteenth century until World War I, and outline some of its effects:

1. Austrian membership in the community of German scientific organizations in the second half of the nineteenth century insured the highest standards of scientific work.
2. The structure of Austrian universities, after 1848 a replica of the German model, ensured that each generation of Habsburg scientists would be trained on a par with their German peers.
3. During the last three decades before World War I dissatisfaction among Austrian scientists with growing budgetary deficits was so great that they preferred to take positions in Germany.
4. Advances in industrialization and technology increasingly provided more jobs for trained chemists and physicists.
5. Increasing enrollments enhanced the importance of university teaching and left less time for research. The result was the establishment of institutions dedicated solely to research, such as the "Kaiser Wilhelm Institut" in Berlin and the "Radiuminstitut" in Vienna.
6. Nationalist strife within the Habsburg Monarchy affected both students and professors. Students were distracted from their studies by rising political ferment, while professors of differing nationalities were pitted against one another in the competition for jobs.
7. The state became an important instrument of educational support and management and directly profited in stature and wealth from its complement of trained scientists.

Together these factors may be seen as proof that there were many external impacts on science in late-imperial Austria. Perhaps predictably however, the most important influence turned on nationalist dissension.

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### Endnotes

1. Justig Liebig, "Der Zustand der Chemie in Österreich," (1838) in Reden und Abhandlungen von Justus von Liebig, Leipzig and Heidelberg, 1874, 1-6.
2. Österreichisches Biographisches Lexikon, Vol. 5, Vienna, 1972, 388-389.
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