# History of Modern Physical Sciences

## Aims and Scope

The series will include a variety of books dealing with the development of physics, astronomy, chemistry and geology during the past two centuries (1800–2000). During this period there were many important discoveries and new theories in the physical sciences which radically changed our understanding of the natural world, at the same time stimulating technological advances and providing a model for the growth of scientific understanding in the biological and behavioral sciences.

While there is no shortage of popular or journalistic writing on these subjects, there is a need for more accurate and comprehensive treatments by professional historians of science who are qualified to discuss the substance of scientific research. The books in the series will include new historical monographs, editions and translations of original sources, and reprints of older (but still valuable) histories. Efforts to understand the worldwide growth and impact of physical science, not restricted to the traditional focus on Europe and the United States, will be encouraged. The books should be authoritative and readable, useful to scientists, graduate students and anyone else with a serious interest in the history, philosophy and social studies of science.

## Series Board



## Forthcoming Title

HISTORY OF MODERN PHYSICAL SCIENCES – VOL. 2

# Stalin's Great Science

## The Times and Adventures of Soviet Physicists


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Chapter 1

# The Great War and the Invention of Soviet Science

During the early years of the 20th century, the prevailing motivation among Russian academic researchers was to catch up with their European colleagues in contributing to the world's body of knowledge in 'pure' sciences, all the while demonstrating sometimes benign but mostly arrogant neglect of practical, 'applied' research. Similar attitudes were common in other European countries as well, but Russian scholars took the ideology of pure science much more seriously and literally.[1] After all, industry offered practically no career opportunities for them, and the only available jobs for scientists in Russia—with very few exceptions—existed at universities and other teaching institutions. The drawbacks of this situation and the degree of disengagement between science, industrial, and in particular military production became obvious with the outbreak of World War I.

The war crisis produced a major shift in scientists' attitudes towards research and its goals. Even university-based scholars started searching for practical and military applications of their knowledge and establishing links with industry. Relatively little could be accomplished in the course of the war itself to compensate for the previous almost total absence of such links, yet the technological inadequacy exposed in the time of a major national crisis stimulated plans and proposals by Russian

[1] On British scientists and their ideology in that period, see (Edgerton 1996)

academics for serious changes in the goals and the infrastructure of the country's scientific effort. Their drafts envisioned the recognition of science as a separate profession from teaching, the creation of a network of research institutes, and a turn towards practical, applied research linked to the military and industrial needs of the nation. Some of the key ideas of those proposals, eventually realized, defined the main characteristic features of the post-revolutionary Soviet system of science.

## 1. Science, Industry, and Military in the Late Russian Empire

"I don't think it is dishonorable for a Russian professor of chemistry to work in the applied direction," Vladimir Markovnikov (1837–1904) of Moscow University defended himself in 1901. Despite the common recognition that chemistry was industrially and economically the most important scientific discipline of the late 19th century, Russian academic chemists took pride in working on "pure" topics. Even though Markovnikov's investigations of the chemical composition of petroleum from Caucasus oil fields had led him to discover important new classes of organic substances, they deviated from the accepted norm and needed a special apology (Solov'ev 1985, 310).

Markovnikov had been drawn into studies of Russian oil by chance twenty years earlier through an invitation to review the state of the country's chemical industry. As no direct industrial statistics were available, he analyzed the existing data on foreign trade and concluded that national industry was capable of producing only the most primitive of chemicals while almost all products that required special chemical knowledge or expertise were imported from abroad. The rapidly developing Moscow textile industry in particular depended on imports not only of synthetic dyes but even of soda from Germany. It was the "fate of all nations who are culturally less developed than others" to be economically disadvantaged when new artificial products are developed in more advanced countries, warned Markovnikov in his 1879 public lecture "Modern Chemistry and Russian Chemical Industry." Having concluded that "one can hardly expect from Russian industry any stimulus for the development of chemistry in Russia," he argued in favor of protectionist tariffs to encourage the production of more sophisticated chemicals (Markovnikov [1879] 1955, 646, 666). After the lecture Markovnikov was approached by the entrepreneur V. I. Ragozin, who offered financial support for a research project on petroleum from Baku



In contrast with the sorry state of the chemical industry, academic research in chemistry—as well as in mathematics and physiology—achieved a very high level of development in late Imperial Russia. By the end of the century, most universities and engineering schools equipped advanced chemical laboratories for their professors' research (Lomonosovsky 1901). In Markovnikov's judgment, Russian chemists were "sometimes ahead of others," even though their studies had a "predominantly theoretical character." His observation resembled typical British complaints of the time: the Russian chemist Nikolai Zinin discovered how to synthesize anilin, which was then used by the British chemist William Perkin to synthesize the first artificial dyestuff, but it was Germany that took all the profits from monopolizing the world's industrial application of these discoveries. Markovnikov complained further that Russian industry suffered from a severe shortage of qualified technicians and at the same time had no jobs to offer to chemists with university diplomas (Markovnikov [1879] 1955, 642, 648).

Even Markovnikov, however, paid tribute to the common cult of his Russian and German peers by insisting that university instruction in chemistry should deviate in no way from the strict norms of pure science, lest its level be compromised. He waited for industry to become sophisticated enough to engage in useful interaction with academic science rather than looked for the latter to step down from its pedestal (Markovnikov [1879] 1955, 672–675). Twenty years later, around 1900, the debate was still alive in Russia over whether the country should industrialize or remain agricultural, even as industrialization was already developing apace with foreign capital and imported technologies, but without a single advanced industrial laboratory or any significant contact with academic science. Markovnikov's focus on applied topics remained, as before, a controversial exception to the dominant attitude among his colleagues. Russian academic chemists enjoyed a great international reputation, and petroleum exports were rising rapidly, but the chemical industry accounted for a pitiful 2.1 percent of the country's total industrial production (Kovalevsky 1900, 242).

Another distinct exception to the prevailing norm was Dmitry Mendeleev (1834–1907), Markovnikov's colleague from St. Petersburg, famous for his invention of the periodic table of chemical elements. A very unconventional academic, Mendeleev ventured far outside his special field of inorganic chemistry, publishing and advising government officials and private individuals on various matters of industrial production, metrology, technology, economics, foreign trade—with regard to which he also favored and helped introduce protectionist tariffs—and politics. Even more unusual for a university professor, Mendeleev also did some important research for the military. Ivan Chel'tsov, chemistry professor at the School of Mine Officers in St. Petersburg, asked him to help the Russian Navy discover the secret of the latest French invention, smokeless gunpowder. Hoping to learn some secrets from the allies, Mendeleev undertook a special trip to France and Britain, reporting afterwards that the French did not want to share much. The British were more open, but their powder was no good. What little he had learned enabled Mendeleev to start experiments in his university laboratory and eventually to offer the Navy his own version of smokeless gunpowder, together with a piece of advice:

> The safe and timely achievement of the goal of providing the Russian Navy with appropriate types of smokeless gunpowder is possible only with the help of an independent scientific and practical study of the problem in Russia, whereby all details would have to be developed by us ourselves, and the appropriate temporary secrecy maintained at the level with which similar activities are pursued in England, France, and Germany (Dmitriev 1996, 137).

The Navy agreed to establish a Scientific-Technical Laboratory in 1891 with which Mendeleev was affiliated until 1895, yet his efforts proved abortive. Mendeleev's version of smokeless gunpowder was tested in 1893, but the rivalry between the Navy and the War ministries impeded its full-scale industrial production (Gordin 2001, ch. 7). By the time of Mendeleev's death in 1907, the project had been abandoned for at least three years, for which Russia paid dearly during the Great War, buying Mendeleev-invented gunpowder from the United States. As for the War Ministry, it did not have any research facility until December 1914—several months into the full-scale European war—when it established its own Central Scientific-Technical Laboratory (Nauka 1920, 117–118).

The situation with applied research at military schools had not advanced significantly further. As a young officer studying at the Grand Duke Mikhail Artillery Academy in St. Petersburg, Vladimir Ipatieff (1867–1952) nourished aspirations to become a chemist. Among his Academy professors was one famous scholar—metallurgist Dmitry Chernov—who had made fundamental discoveries in the fields of steel production and gun manufacturing, but teaching and occasional consulting rather than original research occupied the rest of the faculty. As there was no chemical laboratory to speak of, Ipatieff assembled a small private laboratory in his apartment. Upon graduation in 1892, he became the Academy's instructor in chemistry and—in order to produce the dissertation necessary for the promotion to professorial rank—attended a laboratory at St. Petersburg University. Ipatieff's request for funding at the Artillery Academy was initially turned down by a superior, who



> explained in a soft, insinuating voice, with which he was used to overruling his opponents, why the chemical laboratory never received more than half of its allotted money. ... He said there was no reason why the Academy should appropriate money for a laboratory which had not produced a single scientific investigation in ten years and whose only published dissertation did not describe a single experiment (Ipatieff 1946, 59, 102–109).

Only after Ipatieff had defended his dissertation and been promoted in 1899 to become the Academy's first Professor of Chemistry and Explosives did he manage to organize the chemical laboratory properly. There he soon discovered a new class of catalytic organic reactions occurring under high temperatures with iron as a catalyst, which brought him recognition and fame in the academic world and opened the way for his subsequent groundbreaking studies of chemical catalysis. Even though he taught at a military school and rose to the rank of general by 1910, Ipatieff regarded his laboratory research as "pure organic chemistry," made little if any effort to put his discoveries to use, either military or civilian, and blamed industry for the lack of interest:

> Unfortunately, the Russian chemical industry was too immature to use the scientific discoveries even then available. I still did not bother to take out patents, and once told one of my friends that I was a scientist and wanted complete freedom in my work, which I would not have if I had to be concerned with patents. Had I been a German chemist, I should probably have been infected by the same patent disease as were others. The German chemical industry made full use of my data at no cost to itself (Ipatieff 1946, 174, 178).

Ipatieff recalled that his attitude towards industrial applications started changing in 1913, after a German engineer took out a patent on his discoveries. A major shift in his understanding of what it was to be a scientist, however, occurred as a result of the Great War.

## 2. The War Crisis

Those who watched Russian industry perform during the first months of the Great European War could not escape the conclusion that the country's degree of economic, industrial and scientific dependence upon

Germany was intolerable, bordering on colonial. This was not surprising in the fields of high technology, such as machines and chemicals, where less than half of the needed products were manufactured in Russia (Grinevetsky 1919, 33). But even in industries that could have relied entirely on native materials and supplies some essential parts had to be imported. When the border with Germany closed in August 1914, chaos ensued in the Russian industry, which was unable to find or quickly produce substitutes for previously imported goods. Shocked by this degree of dependence, some observers even suspected a pre-war German conspiracy behind the arrangement (Novorussky 1915). Although diplomats had been expecting a showdown with Central powers for years, plans for the wartime mobilization of industry had not been prepared. The crisis and shortages at the start of the war made many in Russia—as in other countries—envy the German war-oriented management of industries and demand centralized and rational planning of the economy several years before this principle would be declared 'socialist' by the revolutionary Bolshevik government.[2]

Foreign investors dominated the Russian civilian industry, with the usual consequence that it relied on imported technologies and know-how rather than on independent research and expertise. Military industry and major munitions factories were owned by the state, yet even in this traditional field of governmental concern, the prevailing strategy had been buying and copying foreign innovations. As one economic historian has concluded, while some of these factories "yielded to no one in the quality of their product and stood the test of international comparison and competition ... there is no sign that the state sector was the locus of technical innovation or innovation in management style" (Gatrell 1994, 258). The Putilov, Obukhov, and Okhta military factories established modest laboratory facilities during the war, but they were used primarily for routine control of production (Bastrakova 1973, 45). General Aleksei Manikovsky, who during the war was responsible for the supplies of the Russian army, could only complain that "Germany had supplied the entire world, including Russia, with tools of war, and we had paid our money for the development of expensive German military industry" (Manikovsky 1920, 237).

Once the war broke out, the military followed its traditional instincts and turned to allies and neutrals with requests for supplies and technology. Hastily Manikovsky tried to place orders for military equipment in

[2] See the analysis and comparison of mobilization-style economies in Germany, Russia, and other belligerent countries during the Great War in (Bukshpan 1929).



Japan and the United States, an effort that resulted in huge expenditures and limited satisfaction. A year later he came to consider those purchases a mistake and to think that much better results could have been achieved had the resources been directed to the development of native industrial production from the very beginning of the war: "After having spent more than 300 million rubles on foreign automobiles, we now [November 1915] came to the decision to develop our own manufacturing" (Manikovsky 1920, 248). Military officials also gradually recognized the need to develop or greatly expand the production of aircraft, chemicals, radios, optical devices, and other war-related products requiring cutting-edge scientific knowledge and expertise.

The extreme shortage of shells was considered the major cause of the Russian Army's difficulties during the first year of the war. To deal with the problem, the Army's Chief Artillery Administration established a commission for the procurement of munitions. The commission started its work by arranging for major purchases of toluen and crude benzol abroad, primarily in the United States, rather than developing their manufacture in Russia. Ipatieff, who was appointed a member of the commission, recalled that in the early period of the war "[t]he mood in general was one of pessimism with a lack of confidence in our own forces and a feeling of inferiority in the face of German technology" (Ipatieff 1946, 196). That initial decision was regretted and was reversed in 1915 when the commission ordered the construction of the first state benzol plant in the Donets coal basin. The plant started producing in September 1915, and its inauguration was followed immediately by the construction of some twenty more state and private factories and by further work on the production of other war-needed chemicals: benzene, toluen, trotyl, and xylene.[3]

On 26 January 1915 professor-chemist and General Grigory Zabudsky, the commander of the newly created Central Scientific-Technical Laboratory of the army, called a meeting to discuss the technical component of the war. Among other topics, the meeting briefly considered the use of "suffocating and intoxicating gases in shells," which the majority of officers opposed arguing that "such methods can be regarded inhuman and have not been previously used by the Russian army." Still, Zabudsky

[3] On the 'shell crisis' and attempts to purchase materials abroad see (Stone 1975, ch. 7). On wartime production see (Ipatieff 1946) and "Materialy o nalichii proizvodstva i rasshirenii proizvodstva vzryvchatykh veshchestv i promezhutochnykh produktov, 1915" Voenno-istoricheskii arkhiv, Moscow (hereafter VIA) 507-2-37

did not completely rule out possible future uses of poison gases "in case of the enemy's gross abuse of such methods." He ordered the laboratory's department of powder and explosives to conduct research on appropriate substances in order to be ready "in case of an emergency, to start production."[4] The emergency was not long in coming. In late May 1915, one month after the first massive attack with poison gas on the Western front, the Germans used chemical weapons also in the East, at Rawka near Warsaw, causing the Russian army about 9,000 casualties, more than 1,000 of which were fatalities. Only then did the Chief Artillery Administration organize a special Commission on Poison Gases for the production of liquid chlorine, phosgene and other gases for use in shells (Haber 1986, 36–39; Ipatieff 1946, 197–215).

The commissions on explosives and on poison gases merged in 1916 to form the War Chemical Committee, which later added three more departments: Incendiaries and Flame Throwers, Gas Masks, and Acids. The first tests of shells filled with chlorine took place in June 1915. Industrial production of chlorine started in early 1916 and of phosgene later that year. The committee decided to abstain from using cyanide-containing substances unless the Germans used them first, but went ahead with producing chloropicrin—tear gas—and a few other chemicals.[5] Driven by the huge military demand, Russian industrial production swelled during the war years. Employment in the chemical industry rose between 1913 and 1917 from 33,000 to 117,000 workers (Gatrell 1986, 185; Strumilin 1935). The crisis with the production of explosives and shells was resolved, at least partly, by 1916 (Barsukov 1938, 351). Hundreds of tons of poisonous chemicals were also produced, but, according to the available statistics, by April 1917 most of them remained at storage and production sites with only the miniscule amount of 138 pud (just over 2 tons) of liquid chlorine actually delivered to the front.[6] It thus does not seem likely that the

[4] Zabudsky to the Secretary of the General Staff M. A. Beliaev, 29 January 1915. (VIA. 507-3-192, pp. 1–2).

[5] "Pervye ispytaniia snariada s khlorom, 11-12.6.1915," (VIA, 507-3-192, pp. 43–44); "Khod rabot komissii po zagotovke udushlivykh sredstv, 1915-1916" (VIA, 507-3-1, p. 26); "Doklady o khode rabot komissii po zagotovleniiu udushaiushchikh sredstv, 1915–1917," (VIA, 507-3-2).

[6] For statistical data on Russian production of war-related chemicals in 1916–1917 see (Bukshpan 1929, 362–366). For data on the production and delivery of suffocating substances see "Perepiska i doneseniia ob izgotovlenii i perevozkakh udushaiushchikh sredstv, 1915–1917," (VIA, 504-16-20, p. 590).



already decaying Russian army had a chance to use any substantial amount of chemical weaponry.

The war changed much for the Russian academic community as well. It broke scientific communication and contact with colleagues from other belligerent nations, resulting in virtual scientific isolation that lasted about six years, till the end of the Civil War in 1920. No other problem of that period—not even enormous economic and political hardships—caused so

V. N. Ipatieff in 1916, then a Lieutenant General serving on the War Chemical Committee of the Russian Imperial Army. The war reoriented Ipatieff's work in chemistry from research on academic topics to the organization of industrial production of munitions and other military supplies. Later Ipatieff became a chief organizer of the Soviet chemical industry and military research and occupied responsible posts in the revolutionary Bolshevik government. After 1930 he lived and worked in the United States.
[*Courtesy*: Northwestern University Archives.]

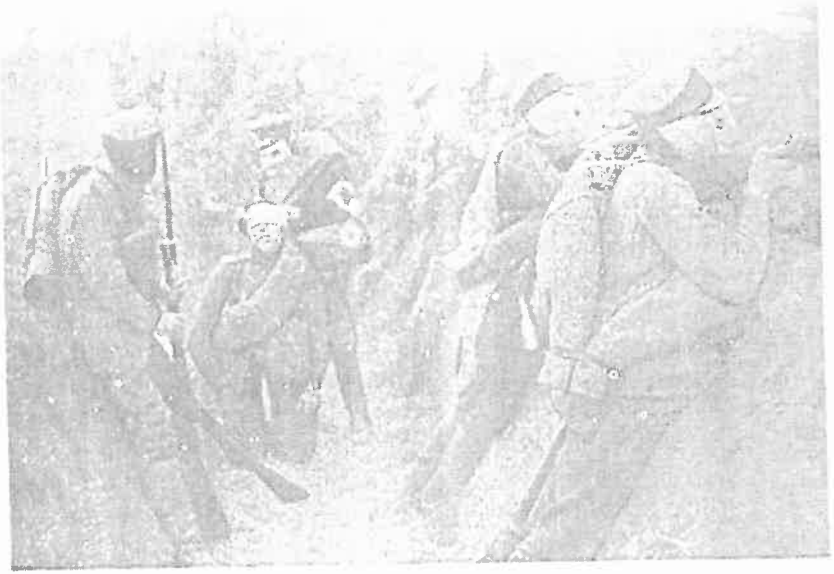
many complaints among Russian scientists, but none also contributed so much to the development of their identity as a national community. Whereas before the war most Russian research was published in foreign and foreign-language periodicals, the war years saw the establishment of national scientific societies in those fields which were still lacking them in Russia and an upsurge in the number of Russian-language academic journals (Aleksandrov 1996).

Perhaps even more important, the war crisis led to a major shift in attitudes towards research and its goals. While Ipatieff and his military peers at the War Chemical Committee were building and mobilizing the chemical industry, civilian chemists started searching for ways to make their contributions to the war effort.[7] Aleksei Chichibabin, chemistry professor at Moscow Higher Technological School, published newspaper appeals to chemists inviting them to join research on medicaments, and to industrialists, arguing that in order to achieve economic independence from Germany "[t]he Russian chemical industry, from the very beginning, must find its basis in Russian science ... and take care of the establishment of most favorable conditions for the quickest and widest development of Russian chemical science" (Chichibabin 1914; 1915). Chichibabin put his laboratory to work on alkaloids for the needs of the pharmaceutical industry and started developing methods for the production of opium, codeine, morphine, aspirin, and other medicaments whose importation had stopped during the war. About 30 volunteers—chemists and chemistry students—joined him in this effort, and in March 1916 the Council of Ministers approved the establishment of an experimental pharmaceutical factory adjacent to the Moscow Higher Technological School for the production of war medicaments (Evteeva 1958, 332–334).

Probably the single most important contribution by a Russian academic scientist to the war effort came from Ipatieff's scientific rival, Nikolai Zelinsky of Moscow University. In 1915 Zelinsky started working on so-called "passive chemical warfare," or protection against poison gases. By the fall of that year he proposed using activated charcoal and developed appropriate chemical methods for the required activation (Zelinsky and Sadikov 1918; 1941). Engineer Eduard Kummant designed a special rubber mask with a container for charcoal, and the manufacturing of the Kummant–Zelinsky mask started in 1916 despite bureaucratic delays and rivalry with other inventors. By the end of the war, Russia had produced

[7] On Russian chemistry and the war, see (Brooks 1997).





Russian soldiers during World War I wearing Kummant–Zelinsky gas masks.
[*Source*: *World War 1914–1918: A Pictured History*, edited by J. A. Hammerton, vol. 1. (1934).]

some 15 million gas masks of several different types (Ipatieff 1946, 218–235; Nametkin 1954, 11).[8]

However important this particular invention was, it only started paying off in 1917 when the country's determination and willingness to wage the war were already collapsing. Overall, the degree of involvement of Russian scientists in the war hardly matched that of their German, British, and French peers.[9] Institutionally and as a community, Russian science came to the situation of national emergency unprepared. With no pre-existing working relationship with either military or civilian industry, even the available scientific expertise and potential could not be used effectively. Connections had to be established in the course of the war itself, which took time and started delivering modest results towards the end of the war. In contrast, the Russian scientists' response to the inadequacies

[8] See also "Opisaniia i chertezhi izobretenii protivogazov i priborov dlia bor'by s otravliaiushchimi veshchestvami, 1915–1917" (VIA, 507-5-72) and "Svedeniia o ezhednevnom proizvodstve protivogazov, 1917" (VIA, 504-16-179).
[9] For comparisons with other national developments and scientific research in the war, see (Dewey 1988; Haber 1986; Hardach 1992; Hartcup 1988; MacLeod 1993, 1998; Trebilcock 1993).

revealed by the war and their public outcry for major reforms were anything but modest.

## 3. The Idea of Research Institutes

In an Empire pregnant with revolution, many monarchists and conservatives were looking forward to progressive change, while among those who under normal conditions would be called moderates radicalism was in high fashion. Even many representatives of the noble and wealthy classes developed distaste for half measures and piecemeal, compromise solutions, preferring, at least in posture, revolution to reform. The spectrum of proposals for social change favored by Russians reflected many common international trends of the early 20th century, but tended to be more radical in demands, more uncompromising in tone, and more urgent in time schedule. Ideas for reform in science proposed by Russian scientists display very similar characteristics. For example, the public value of research versus teaching was rising in all major scientific powers, but in late Imperial Russia this tendency took the form of a demand that scientists should be liberated from teaching obligations altogether and recognized as a separate profession with their own specialized institutes for research. After several twists and turns during the turbulent second decade of the century, this idea materialized in revolutionary Russia and eventually became the single most characteristic feature of the Soviet system of science.

The adage that "the success of science (and technology) is impossible without emancipating the modern scientist from his obligations as a teacher" is due to Kliment Timiriazev (1843–1920), the famous plant physiologist from Moscow University, popularizer of Darwinism and a radical democrat by political convictions. Timiriazev came to this conclusion in 1911 in response to two important events of that year, the infamous Kasso affair in Moscow and the founding of the Kaiser Wilhelm Gesellschaft in Berlin. A few months earlier, the governing body of Moscow University, its Academic Council, was caught in a conflict between radical students and the police. A student meeting on the university campus in memory of the recently deceased Count Lev Tolstoy was viewed as political, and therefore illegal. After all, Tolstoy was not only the country's greatest novelist, but also a dissident religious thinker officially excommunicated from the Russian Orthodox Church. The police entry to campus in order to prevent students from meeting was also illegal, as it violated the principle

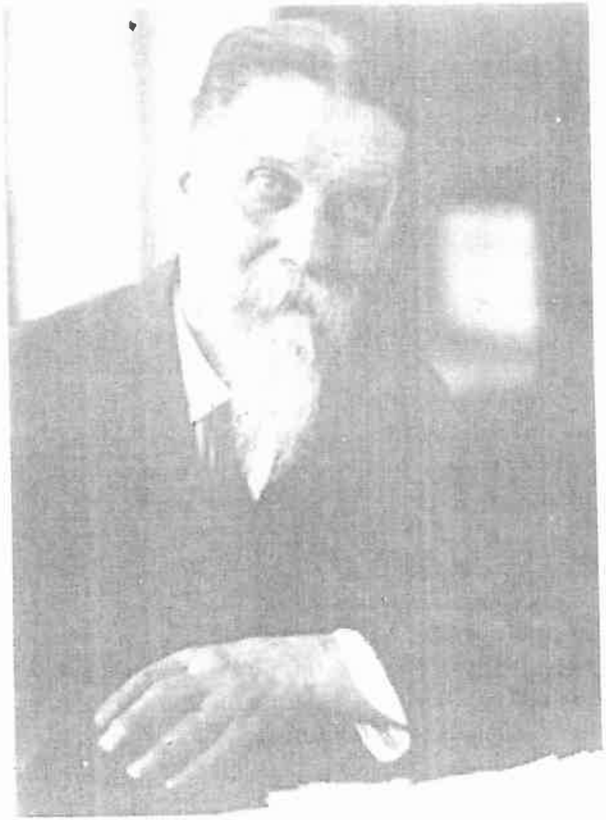


of university self-governance. In protest of this violation, the rector, Aleksandr Manuilov, and two other high elected officials of the University, Mikhail Menzbir and Piotr Minakov, resigned from their administrative posts. To reprimand them, the minister of Enlightenment, Lev Kasso, not only accepted their resignations as administrators, but also fired them from their professorial positions. This abuse of power triggered a wave of solidarity resignations among other members of the Academic Council. In total, about a quarter of the faculty—more than 100 professors and privat-docents—resigned, a rather bold act since only a few of them could have reasonable hopes of obtaining positions elsewhere, outside the system of state schools.[10]

Never before—except perhaps in the devastating fire during Napoleon's occupation of 1812—had Moscow University experienced such a damaging blow, and the public outcry against government "obscurantism" ran high, especially in the Moscow press. Since Timiriazev had already reached retirement age, his personal resignation was largely an act of symbolic protest, but as a public figure he was one the principled and most vocal critics of the regime. Other timely news arrived from the foreign press, allowing Timiriazev to discuss the treatment of science in the favorite Russian genre of political discourse by juxtaposing and contrasting Russia to some mythical, undifferentiated "West." Typical for "us," in his narrative, was the pogrom of Moscow University faculty by Kasso and state bureaucrats, while characteristic for "them" was the opening ceremony of the Kaiser Wilhelm Gesellschaft in Berlin with its projected dozen research institutes. Although one might question the value of the genre of festive speeches as a source of real information, Timiriazev extracted from Emil Fischer's opening address the conclusion he wanted: that Germans held science in such high regard as to establish separate institutes for researchers "without teaching obligations" (Timiriazev [1911] 1963).

Timiriazev was not only an influential scientist but also a true democrat. His unreserved belief in science was matched only by his unreserved belief in democracy and, furthermore, by the insistence that the two had to go hand in hand. Such views in the early 20th century—when Germany led the world in many sciences—were somewhat counterfactual, but Timiriazev was not discouraged by this inconsistency. He was confident

[10] See the description of the Kasso affair in P. N. Lebedev's letter to F. A. H. Krüger, February 1911 (Lebedev 1990, 358–359). For a general study of the conflicts at Russian universities in the early 20th century, see (Kassow 1989).



K. A. Timiriazev late in his life, around 1920. The plant physiologist Timiriazev was the major authority on, and proponent and defender of, Darwinian evolutionary theory in Russia, where his role was similar to that of T. H. Huxley, "Darwin's bulldog," in England. In 1911 Timiriazev put forth the idea of organizing scientific research in special institutes outside the universities, which later became the dominant Soviet trend. Shortly before his death in 1920, he publicly endorsed the Bolshevik regime, thus helping to forge the pact between research-oriented scientists and the Soviet government.
[*Courtesy*: K. A. Timiriazev Museum, Moscow.]

not only that science under Anglo-Saxon democracies must be much better off than in imperial Germany, but also that it had surely advanced further in the progressive trend of liberating science from teaching. He had heard something about the Carnegie Institution of Washington and about the "endowment of research" in Britain, and he misinterpreted these examples as proof for his claim (Timiriazev [1911] 1963, 58).



In accordance with the rules of the genre of writings about "Russia and the West," Timiriazev depicted his country as backward for still having "all its science concentrated in universities" while "the entire civilized world" had recognized the highest value of research itself. The massive resignation of Moscow professors had proved to him that scientists could not be free as long as they remained in their teaching positions as state employees. The Kasso affair indeed destroyed the international pride of Moscow science, Piotr Lebedev's laboratory in the cellar of the Moscow University's Physics Institute.

Lebedev (1866–1912), a son of a Moscow merchant, defied his father's wishes by choosing an academic career. After receiving a Ph.D. in Germany, he returned to Moscow and defended another dissertation for a Russian doctoral degree, which was necessary for a professorial career at a Russian university. In 1903 the Moscow University opened a new specially designed building for its Physics Institute, and the recently appointed Extraordinary Professor Lebedev started creating there a German-style research school. He had already won an international fame for a series of very delicate experiments in 1899–1900 in which he succeeded in measuring the mechanical pressure produced by light, thus experimentally confirming the last remaining great prediction of Maxwell's electromagnetic theory. Lebedev regarded advanced research and the training of research students as his primary job obligation, and in this he was a perfect example of the so-called "research imperative" taking hold of Russia by the turn of the century. The Russian universities followed in this respect the most advanced system of research-oriented German universities, and this was also where Lebedev drew his main professional inspirations. The Physics Institute at Moscow University was designed according to the best German models as a three-story building with a lecture hall, apartments for professors, experimental *Praktikum* for students, and laboratories for research in the cellar. Like his German teacher August Kundt, Lebedev started gathering a following among advanced students and instructing them in performing cutting-edge research. By 1911, there were about two dozen of them at various stages of work in his laboratory, and a few were already completing dissertations and looking around for jobs. Though Lebedev was not very active politically, he felt obliged to resign in solidarity with other professors as a result of the Kasso affair. He and most of his students left the university in 1911, abandoning a well-equipped laboratory and the possibility of continuing a productive research program (Lebedev 1990).

Timiriazev through newspapers appealed to Moscow merchants to save "their" Lebedev and help create "safe havens for scientific research" in the form of research institutes independent of state universities. He remained fully convinced that his proposal to separate science and university education was following the general trend of more developed countries rather than embarking on an original path of institutional development (Timiriazev [1911] 1963, 58, 65). His call found a warm reception among many other scientists and publicists, but the idea developed further in two distinctively different forms. Timiriazev and other Moscow authors argued for the establishment of non-governmental facilities for research and looked towards private philanthropy for support. Like Lebedev, many Moscow professors came from the merchant estate themselves or had personal ties to families of major local merchants and industrialists, who by the early 20th century had developed a taste for cultural philanthropy (Buryshkin 1991). The initiative of professors who resigned resulted in the founding of the (awkwardly named) Moscow Society for Scientific Institute in 1912 with the purpose of raising private funds and donations for the construction of non-governmental research institutes (Zernov 1912). Four such institutes—in physics, chemistry, biology, and social sciences—were planned, and two were actually built despite the on-going war. After Lebedev's premature death of heart disease in 1912, his student Piotr Lazarev (1878–1942) continued pushing forward the construction of the Physical Institute and eventually became its director, while the Biological Institute came to be directed by Nikolai Kol'tsov. Both institutes opened in 1917 on the eve of the revolution, and they later became the nuclei of the much larger Soviet institutions.

In contrast to Moscow academics, their colleagues in St. Petersburg had much closer relations—personal and otherwise—to the state bureaucracy and typically looked to the government as a source of patronage. The Imperial Academy of Sciences in St. Petersburg used the occasion of Mikhail Lomonosov's bicentennial in 1911—marked by the festive official celebrations of the proclaimed founding father of national Russian science—to lobby for the establishment of a large Lomonosov Institute for research in three fields: physics, chemistry, and mineralogy. The proposal received His Majesty's approval but was later postponed because of the Great War and never materialized (Bastrakova 1999; Imperatorskaia 1917, 102–106). The idea of state research institutes, however, did not die. Another major spokesman for Russian science, Vladimir Vernadsky (1863–1945) of the Academy of Sciences, modified it according to the new situation during the war and took first steps towards its practical realization, with huge consequences for the post-revolutionary period.



## 4. The Study of Natural Productive Forces

World War I cultural propaganda centered around the theme of the holy struggle between civilization, culture, and barbarity. Russia's traditional dependence on Europe, particularly Germany, made it harder for Russian authors to use the language of militant cultural nationalism that permeated the writings of French, German, and British war ideologues. Russian educated elites could easily formulate their opposition to the "Teutonic race" in nationalistic, monarchist, religious, or moral terms, but not in terms of cultural superiority. Instead they pictured Russia's war as a war for cultural and economic independence against the cultural imperialism of Germans. Once the war broke out, Russian writers who had previously decried the country's backwardness in inflated terms started calling its lack of culture only "illusory" and claiming that "the victory over Germany is necessary in the name of [European] culture" (Brenchkevich 1915, 32; Grimm 1915, 14–15; Trubetskoi 1915).

Compared to religious philosophers, scientists in Russia had even fewer reasons to claim nationalistic cultural superiority. Unlike their Western colleagues, they typically produced rather moderate, almost internationalist statements and complained most strongly about the damage done by the war to international exchange and communication in science. The pacifist Timiriazev was on the left side of the political spectrum and even during the war continued to proclaim science as a universal, international, and rational activity, denouncing all its military applications (Timiriazev [1915] 1963). Vernadsky, geologist and geochemist, was much closer to the political center and also much younger. He was one of the leaders of the constitutional democrats, the political party of liberal opposition in late Imperial Russia that favored the establishment of a constitutional monarchy. It was nicknamed "the party of professors," since its Central Committee consisted mostly of established academics. Vernadsky had also resigned from Moscow University during the Kasso affair of 1911; he was later elected to the Imperial Academy of Sciences and moved to St. Petersburg. As the major wartime public spokesman for science, he represented the Academy rather than universities (Mochalov 1982; Bailes 1990).

The war had a great impact on Vernadsky's scientific and social views. He felt that the tremendous movement of human masses during the mobilization resembled the power of geological forces, which prompted his investigation of global geological effects of human activities, a long line of inquiry that established his later reputation as one of the founding fathers of ecological thought. In historical terms, Vernadsky predicted that the on-going war—like the decades of European wars after 1789—would mark the transition to a new historical era, in particular with regard to the role and the importance of science "because of its real applications to the interests of defense, despite moral reservations" (Vernadsky [1916a] 1922, 54). Like most Russian scientists, Vernadsky lamented the interruption of scientific contacts between belligerent nations, mistakenly believing that scientific research in other European countries continued on its prewar scale:

> As we know, we are continuing our scientific work with the same speed. Our work is developing and improving now, and it also had not been interrupted or slowed down in the years of our other national disturbances—either during the war with Japan or in the years of the revolution [of 1905] (Vernadsky [1915a] 1922, 135).

Whether Vernadsky understood it or not, his statement reflected the fact that Russian science was much less integrated into the total war effort than science in Britain, Germany, or France. He acknowledged, at least, that it was ill-prepared for the new tasks, and he expected major changes in the immediate postwar period: "[Although] the development of science will not stop the war, ... regardless of the outcome of the war, both winners and losers will have to direct their thought towards further development of scientific applications to the military and navy affairs" (Vernadsky [1915a] 1922, 131–132).

According to Vernadsky, the most important task facing postwar Russian science would not be the competition with other nations in pure science but the study of Russia's own natural resources and productive forces:

> Russian society has suddenly realized its economic dependence on Germany, which is intolerable for a healthy country and for an alive strong nation. ... [This dependence] has transcended the limits of necessary, unavoidable and profitable exchange of products of nature, labor, and thought between two neighboring nations. It has developed into an exploitation of one country by the other. ... One of the consequences—and also one of the causes—of Russia's economic dependence on Germany is the extraordinary insufficiency of our knowledge about the natural productive forces with which Nature and History had granted Russia (Vernadsky [1915b] 1922, 5).

By his count, only 31 out of 61 economically useful chemical elements were mined and produced in Russia. Even aluminum had to be imported, since deposits of bauxite had not yet been explored. Vernadsky believed that practically any useful mineral could be found in the country's enormous territory and referred to this work as "necessary for national security," since Russia had to catch up with other nations in this regard (Vernadsky [1916a] 1922, 65). Following his proposal, in February 1915 the Imperial Academy of Sciences abandoned its century-long tradition of concentrating on pure science and established a Commission for the Study of Natural Productive Forces of Russia (KEPS) (Kol'tsov 1999, 14–15). The task of KEPS, according to Vernadsky, encompassed the study of all kinds of national resources and called for collaboration and mobilization of geologists, mineralogists, zoologists, botanists, chemists, physicists, and even social scientists, following the example of the wartime "mobilization of various engineers who work on the basis of exact sciences, physicians, bacteriologists, and ... chemists." Vernadsky was aware that these plans could be realized fully only after the end of the war, but he insisted that preparations had to start right away. He did not worry too much about wartime expenditures on the project, which would bear fruit only in the long run because "one can establish all the necessary research institutes at the expense of just one super-dreadnought" (Vernadsky [1916a] 1922, 54–55, 68).



With regard to these mobilization plans, science and scientific manpower began to be considered among the country's most important resources. The Academy in Petrograd together with the editorial board of the Moscow scientific periodical *Priroda* established a joint commission to prepare the first national census of academic populations and institutions. In early 1917, questionnaires were distributed to all known scholarly institutions in Russia, and the answers were collected by the year's end from both capitals—Petrograd and Moscow—and from the majority of provinces. Because of the revolutionary unrest, the results of the survey could not be published as planned in early 1918. With financial help from the Bolshevik's Commissariat of Enlightenment, the two volumes were published a couple of years later, containing unprecedented demographic information on science and scientists in Petrograd and Moscow almost exactly on the eve of the November 1917 Bolshevik coup (Nauka 1920–1922).

### 5. The Network of State-Sponsored Research and Development

Vernadsky did not need to wait for the results of the census to declare in 1915 that the war had revealed that the existing scientific infrastructure was totally insufficient for the proposed grand project and that cardinal changes were needed as badly there as in Russia's political system:

> After the war of 1914–1915 we will have to make known and accountable the natural productive forces of our country, i.e. first of all to find means for broad scientific investigations of Russia's nature and for the establishment of a network of well-equipped research laboratories, museums and institutions.... This is no less necessary than the need for an improvement in the conditions of our civil and political life, which is so acutely perceived by the entire country (Vernadsky [1915a] 1922, 140).

Itself an assembly of research laboratories by statute, the Academy of Sciences in terms of its financing was one of the institutions of the royal court and thus naturally expected state patronage. The support it already had, however, was certainly inadequate for the proposed goal of KEPS, but Vernadsky insisted that the work had to start immediately without waiting for the war's end. As the first step, he proposed the preparation of a series of detailed summaries of the available knowledge on Russia's energy, minerals, ores, plants, animals, and chemical factories. He specifically listed some minerals that were in great demand and had to be searched for without delay. With an initial modest contribution from the Academy's budget, KEPS commissioned a number of scientists to write such reviews, which were published as the series *Materials for the Study of the Natural Productive Forces of Russia.*

Reviewing the results of the first year, Vernadsky formulated an ambitious plan of further reform directed towards "a new organization of scientific work" on the national level. His scheme consisted of (1) a national congress of scientists for the discussion of the study of productive forces, (2) coordination of scientific work for the sake of planned research, and (3) creation of new research institutions: museums, laboratories and institutes. Vernadsky specifically elaborated on the last point, arguing that the entire national network of specialized research institutes of applied, theoretical, and mixed nature was needed as a matter of state priority and that KEPS should draft plans for them. He was convinced that "the higher schools alone cannot satisfy the growing needs of scientific research" and therefore of the "impossibility and the disadvantage of the permanent linking of all scientific research work to the institutions of higher education" (Vernadsky [1916b] 1922, 29).

In his 1916 report to KEPS, Vernadsky mentioned plans for an institute on clay and aluminum, and for an experimental station on Kara-Bogaz Bay on the Caspian Sea (a deposit of raw salts). In the following year,



KEPS drafted proposals for a half-dozen more research institutes and laboratories of applied aims (Platinum, Physico-Chemical Analysis, Hydrology, Alloys and Metallography, Petroleum), while learned societies proposed several more (Metallurgy, Pharmaceuticals, Chemical Reagents, Coal) (Bastrakova 1973, 46–49). The idea of separate research institutes thus appeared again, but this time in the form of a much broader and comprehensive network and within the context of the important practical task facing the nation.

Many years later, some Soviet historians referred to Vernadsky's proposal of 1916 as a prophetic anticipation of the Soviet system of planned research with the Academy as its highest administrative body. "Anticipation" is probably too strong and simultaneously too weak a term. The two developments were separated by two decades of revolutionary social changes and are clearly not identical. At the same time, there is not just similarity but a real causal progression linking them together. Vernadsky's wartime proposal represented an important early stage in the process of reform that eventually resulted in the Soviet system of scientific research and development. This connection has been somewhat obscured by the persistent tendency among historians to see the revolution of 1917 and the Bolsheviks as the origin of all new and important developments of the Soviet era. The preceding period of World War I has thus been overshadowed in perceived importance by the subsequent great revolution and has received undeservedly little attention in the history of Russia, in comparison to that of other European countries. In summarizing the results achieved by the Russian Empire, historians typically chose 1913, the last year of peace, with the new society seen as starting in 1917 and the intermediate war presented as disintegration leading to a disgraceful end rather than as marking the emergence of something new and important.

Recently, several important historical studies have started challenging this stereotype, so that a new image of the Great War is gradually emerging, that of a beginning at least as much as an end.[11] More precisely, one can see that the new Soviet society, in many of its essential features, was born during a period of permanent war—1914 to 1921—and retained for at

[11] A similar approach has also been developed in (Holquist 1997; Hoffmann and Holquist, forthcoming). With regard to science, Nathan Brooks (1997, 360) has already noted that "for chemists, the period from World War I through the early years of the Soviet regime was one of relative continuity, not discontinuity." Several recent books indicate the rise of historical interest towards the role of World War I in Russian history (Pisarev and Mal'kov 1994; Mal'kov 1998; Smirnov 1999)

least several decades some of the acquired birthmarks. With respect to the image, institutions, and practice of Russian science, it is possible to say that the new Soviet system was invented even before the revolution of 1917.

To be sure, not all of the mature system's features could already be seen emerging at that early stage. For example, the Academy of Sciences was not yet as dominant among academic institutions as it would eventually become. Although some aspirations for administrative grandeur were present all along and were reflected in Vernadsky's 1916 proposal, the Academy would not be able to achieve this goal until some twenty years later in the mature Stalinist society (Vucinich 1984). For the immediate turbulent decade of wars and revolutions, however, the significance of the Academy and KEPS would be less in overseeing and administering than in part encouraging, in part coordinating, but most of all reflecting the general trend. Similar processes were developing largely independently at various locations and institutions throughout the Empire, as formerly "pure" academics were turning towards economically and militarily important work, establishing nuclei of new research institutions, and preparing blueprints and proposals for an expanded postwar activity along these lines. It was specifically these wartime proposals and activities, which—after 1917—provided the foundation for the emerging special relationship between science and the new revolutionary government.

Chapter 2

# Socialist, or Big, Science

The revolution and its impetus towards radical social change helped advance the reform drafted by Russian scientists during the Great War and allowed it to materialize faster and more thoroughly than comparable proposals discussed by scientists in other countries. Many of the new scientific projects appealed to the revolutionary mentality and modernist ideology of the new Bolshevik government and were quickly adopted and adapted by it. The Bolsheviks endorsed particularly strongly the establishment of research institutes, which won them allies among research-oriented scientists while also helping the Bolshevik struggle for political control over universities. During the Civil War, amid economic destruction and hardships, radical institutional changes in the social infrastructure of science were pushed forward with astonishing ease. As the war and the attendant isolation of Russian science ended in 1921, the foundation of a novel government-sponsored system of research and development was already in place.

For contemporaries, this new system represented the socialist way of organizing scientific research. Yet it also contained the key features of the later, international phenomenon known as "Big Science." The new scientific institutes were organized and funded by the government, they tended to exist independently of, or at least separately from, universities and other institutions of higher education, and their workers received salaries for doing research rather than teaching. These institutes were