Continuity amid Change: Science, Technology, Environment, and Medicine across Russia's Great War and Revolutions

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The onset of the Great War in August 1914 unleashed a maelstrom of violence and destruction previously unmatched in human history. Facilitated by the technological and scientific advances of the "Second Industrial Revolution," which had unfolded in the preceding decades, combatant states entered the conflict armed to the teeth with machines and methods capable of killing on an industrial scale. On land, rapid-firing artillery, machine guns, bolt-action rifles, hand grenades, and barbed wire contributed to the conflict's catastrophic casualty rates. At sea, mines, torpedoes, heavily armed, iron-clad battleships, and submarines sent tens of thousands to watery graves. Meanwhile, tactical radio signaling, radio jamming, and tethered observation balloons extended the war into the third dimension as airplanes and zeppelins threatened soldiers and civilians alike with death from above.

Significantly, none of these devices were new; all had debuted during earlier conflicts. But it was during the Great War that each realized its destructive potential, raised to new heights of precision and acuity through massive investment in research and development that expanded apace as the war ground on. Of the military advances associated with the conflict, only two debuted during 1914–18: tanks, which did not transform combat operations until the interwar years, and chemical weapons, which proved only precursors to a greater holocaust to come.

Just as the Great War spurred improvements in technology, it likewise acted as a catalyst for advances in science and medicine. Confronted by the monumental challenge of caring for millions of wounded and sick combatants, doctors, nurses, field surgeons, and military commanders developed an array of techniques and methodologies that transformed medical practices. Mobile x-ray units, new antiseptics, advances in orthopedics, and the significantly expanded use of vaccines to treat infectious diseases were but a few of the Great War's legacies. The conflict also inspired the development of psy-

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chiatry and plastic surgery as physicians grappled to treat the mental and physical traumas suffered by millions of survivors.

The innovations inspired by the Great War extended beyond machines and men to the landscapes in which they fought. Years of large-scale trench combat, massive artillery barrages, poison gas attacks, and strategic operations aimed at disrupting food supply chains wreaked havoc on rural and urban areas, leading statesmen and civilians to devise new ways of conceiving and interacting with the environment. Although scholars have only recently begun to study this aspect of the Great War, the conflict's role in reshaping the natural world was profound.

Of course, the Great War was but the first act in the "continuum of crisis" that enveloped Eurasia from 1914 until the early 1920s.[1] Before the crisis had run its course, the region's political landscape was radically changed. The autocratic dynasty which had ruled the multiethnic Russian Empire for more than three hundred years was replaced by a revolutionary state whose Marxist leaders aimed to eradicate the past in favor of a futuristic new world predicated upon theoretical models derived from "scientific" socialism.

What appeared simple in theory proved elusive in practice. The transformation of backward, agrarian Russia into an advanced industrial state would prove a monumentally difficult task for the Bolshevik Party leadership. Foreign circumstances in the immediate postwar period further complicated matters. The absence of the forecast world-wide workers' revolution in the wake of October 1917 left the country isolated internationally. Bolshevik policies made their new state a diplomatic pariah. Decisions to sign a separate peace with Germany and to cancel the country's massive international debts along with continuing efforts to export revolution abroad intensified opposition from Western governments. The new regime weathered the resulting storms of civil war and foreign intervention thanks to better organization and communications, coupled with a lack of coordination and resolve on the part of its adversaries. The widespread application of indiscriminate violence also helped. A negotiated ceasefire with Poland in the fall of 1920 removed the last significant foreign threat to the state but serious challenges remained.

As the Bolshevik Party shifted from defending the October insurrection to administrating and organizing Russia's broken and ravaged countryside, the recently concluded world war loomed large. Like Peter the Great, Sergei Witte, and other imperial statesmen before him, Vladimir Il´ich Lenin was convinced the country's future depended upon matching levels of technological innovation and scientific discovery already achieved by Western societies.

[1] Peter Holquist, *Making War, Forging Revolution: Russia's Continuum of Crisis, 1914–1921* (Cambridge, MA: Harvard University Press, 2002).

The events of 1914–18 were instructive in this regard. Writing in the aftermath of the Brest-Litovsk peace in March 1918, Lenin remarked:

> The war taught us much, not only that people suffered, but also the fact that those who have the best technology, organization, discipline, and the best machines emerge on top; it is this that the war has taught us. It is essential to learn that without machines, without discipline, it is impossible to live in modern society. It is necessary to master the highest technology or be crushed.[2]

Lenin was not the only Bolshevik leader who recognized the developmental imperatives imposed by total war. Lev Davidovich Trotskii likewise believed that the experiences of 1914–18 underscored the centrality of technology and science to the Bolsheviks' future. In the short term, he proposed to re-establish and sustain productivity through the regimentation of society after the fashion of an army. In the longer term, he argued, the "discipline" that Lenin called for would be attained by mobilizing technology and science to serve the party and state.[3]

By directing state authority and resources toward the acquisition of technological instruments and the promotion of scientific advances, the Bolshevik Party could overcome the historic obstacles posed by Russia's vast territories and isolated, illiterate populations. However, where technology and science had previously been put to use waging total war against foreign adversaries, they would now also be mobilized to wage total war against the internal scourges of backwardness and ignorance. Tractors, airplanes, hydroelectric stations, and modern sanitation methods would facilitate the advent of socialism by elevating living standards, ending isolation, and contributing a sense of national unity and purpose. At the same time, robust technological, scientific, and medical infrastructures would advance the long-term cause of socialist construction by raising the Soviet Union to a level on par with the capitalist world. In this way, the technological and scientific objects of Bolshevik desires came to be seen as the very means of Bolshevik success. To achieve the dialectical synthesis of present and future that would lead to the advent of socialism, party officials looked to wed Western technology and productive methods to organizational and ideological forms of their own design.

Ultimately, as the essays in this volume collectively reveal, early Bolshevik policy toward scientific and technological progress reflected less a revolutionary "break" with past practices than the continuation (albeit it on a

[2] V. I. Lenin, *Polnoe sobranie sochinenii* (Moscow: Politizdat, 1969), 36: 116.

[3] L. D. Trotskii, *Sochineniia* (Moscow–Leningrad: Gosizdat, 1927), 21: 383.

grander scale) of institutional methods longstanding in Russian history. Party leaders fell back upon the power of the state to mobilize economic, materiel, and human resources for the task of modernizing an underdeveloped and devastated country. Like their imperial predecessors, they looked to force the scope and speed of development by leveraging foreign technology and science to achieve domestic aims.

Part 1: "Science, Technology, and Politics"

In the volume's opening chapter, "Scientific and Industrial Research in Russia on the Eve of and during the First World War," Dmitrii Saprykin revisits longstanding debates regarding the Russian appropriation of foreign capital and technical expertise to achieve modernization by way of examining the preparedness of imperial state and society to meet the demands posed by global conflict. Saprykin re-examines the earlier work undertaken by economic historians including John McKay and Paul Gregory in arguing that the expansion of Russian scientific discovery and technological innovation in the decade immediately preceding the war was more robust and reliant upon native ingenuity than previously recognized.

Although he acknowledges the central role played by state investment during the 1880s and 1890s in creating foundations for future growth, Saprykin contends that by the turn of the century declining levels of foreign investment, new ranks of native-born scientists and technical specialists, and heightened contributions from nonstate actors (including civic organizations, professional societies, and private business) had eclipsed both state agents and foreign entities as the principal drivers of Russian development. While the strains of the war spurred greater degrees of centralization and militarization, in the end, Saprykin concludes, "Soviet scientific and technical achievements of the 1920s and 1930s were built upon foundations established prior to the Revolution of 1917."

The Great War's function as a fulcrum for scientific-technical innovation and economic development is explored in more detail by Erki Tammiksaar in a chapter devoted to oil shale—a relatively common organic-rich sedimentary rock that may be processed into a liquid hydrocarbon energy known as "shale oil." First devised in the 1850s by the Scotsman James Young, the process of distilling oil shale into shale oil (and accompanying combustible gasses) helped to fuel Scotland's rise as a center of 19th-century British industry. While recent advances in hydraulic fracking have made mining oil shale viable, historically, shale oil's lower efficiency, reduced heating content, and significant developmental costs meant it was a less desirable energy alternative than conventional crude oil or coal.

As Tammiksaar demonstrates, the onset of the Great War prompted imperial Russian scientists and technicians to pursue innovative solutions to the challenges born of the conflict. Chief among these was the need to generate and distribute the energy required to keep the country's factories and enterprises running. Desperate to resolve the critical fuel shortage that befell Petrograd beginning in spring 1915, Russian geologists and engineers backed by state ministers looked to the extensive deposits of oil shale contained in the peat bogs of Estonia's Kuckers region as a potential resource for meeting the capital city's energy needs. After geological studies and ensuing experimental tests demonstrated the resulting shale oil could be used in existing factory furnaces and household fireplaces, an ambitious plan to undertake large-scale mining operations was launched against the backdrop of rapidly deteriorating political and social circumstances.

Tammiksaar's account of the literal resourcefulness demonstrated by Russia's wartime scientists and engineers reinforces Saprykin's contention that the empire's naative specialists matched the ingenuity and innovation attributed to their European and American counterparts. All the same, their creative efforts did not benefit the Russian state. The worsening financial constraints and growing political chaos that unfolded after the tsar's March 1917 abdication prevented the first shipments of shale oil from reaching Petrograd until after the Bolshevik Party seized power the following October. The subsequent occupation of the Kuckers region by the German army, followed, in due course, by the emergence of an independent Estonian nation, produced an unlikely example of local technology transfer. The shale oil industry established by Russian ingenuity came to serve as the principal energy source for the newly established Baltic state.

Russian mining engineers' capacity to adapt to the difficulties imposed by war and revolution extended far beyond Estonia's Kuckers region, as Dag Avango, Vasily Borovoy, and Julia Lajus demonstrate in their chapter, "Technological and Entrepreneurial Visions in Russia's Quest for Arctic Coal, 1912–25." A detailed account of international efforts to secure and exploit the natural resources of the Spitsbergen (Svalbard) archipelago during the opening decades of the 20th century, their investigation underscores Russians' impressive facility for technical innovation while operating in challenging international and environmental contexts.

First discovered in the late 16th century by the Danish explorer Willem Barentz, the Spitsbergen archipelago was firmly established by the mid-1700s as an international destination for hunters and whalers in search of animal fats used to heat and illuminate homes throughout Europe. As the 19th century drew to a close, the discovery of extensive, high-quality coal deposits attracted renewed interest in the island chain. All the same, Spitsbergen's iso-

lated location, brutal Arctic climate, and limited accessibility (resulting from ice-bound conditions that last up to nine months out of the year), contributed to its prolonged status as an unclaimed "no-man's" land; not until 1920 was Norwegian sovereignty over the archipelago formally recognized via international treaty. In the interim, business interests and state agents from Norway, Sweden, the UK, and Russia, as well as the USA, engaged in a delicate and, at times, acrimonious competition to secure the region's environmental treasures.

The international race to lay claim to the archipelago intensified during the Great War as the demands of industrialized combat significantly expanded the need for fuel to power military-related factories and enterprises. As the authors document, imperial Russia was well-positioned to exploit Spitsbergen coal deposits thanks to Rudol´f Samoilovich, a mining engineer and political exile whose extensive knowledge of the region, administrative aptitude, and entrepreneurial acumen were matched by very few, if any, of his peers. During 1914–16, Samoilovich put his expertise and experience to use in developing cost-effective procedures for mining and shipping coal from the remote island chain to energy starved cities including Petrograd and Arkhangel'sk. He simultaneously built a network of scientists, entrepreneurs, and officials to advance state claims to control the territories mined by Russians. Although capital scarcity and the chaos that followed the autocracy's collapse prevented Samoilovich from realizing his wartime plans, his knowledge and radical political bona fides enabled him to continue serving the state long after the advent of Soviet power. In 1920, he played a key role in establishing the Northern Scientific-Fisheries Expedition which, by 1930, would evolve into the All-Union Arctic Research Institute—an organization Samoilovich successfully directed until his 1938 arrest and subsequent execution during the Stalinist Terror.

Per Högselius provides a third take on the energy sector in a chapter chronicling the crisis that befell Russia's petroleum industry across war, revolutions, and civil war. A striking reminder of the axiom that nontechnical factors play a determinative role in shaping technological policy, "The Last Days of the Nobels: Oil and Geopolitics in the Caucasus, 1917–1920" describes the doomed efforts undertaken by managers of the Nobel Brothers Petroleum Production Company (Branobel) to stave off the loss of their Baku-based production, refining, and distribution network.

Established in 1870 by the Swedish brothers Alfred, Ludvig, and Robert Nobel, Branobel quickly rose to a position of prominence in the last decades of the 19th century as the world's leading producer of petroleum, an as yet new form of hydrocarbon energy. Although the company's global dominance dissipated after 1900 owing to aggressive competition from American producers

(most notably Rockefeller's Standard Oil) and the revolutionary chaos that engulfed the Caucasus region and empire in 1905–06, by the eve of World War I, Branobel's ethnically Swedish administrators, led by Emmanuel Nobel (son of Ludvig), had managed to secure the company's steady profitability.

Thanks to the company's role as the chief supplier of petroleum to the state, the onset of the Great War strengthened Branobel's financial bottom line. Shareholders watched their fortunes grow considerably even as the battlefield fortunes of the tsar's army waned. Bolstered by substantial capital reserves, company executives took a "wait and see" approach when labor unrest grew apace following the collapse of the autocracy. As smaller rival companies abandoned the Caucasus amid mounting chaos in 1917, Branobel's leadership responded to workers' demands with generous concessions in a strategic bid to protect material and personnel assets until the return of peace.

Unfortunately, peace was not in the offing. As the Civil War intensified, chaos enveloped the Caucasus. Company officials struggled to provide employees some relief from the scourges of starvation, rampant disease, and widespread ethnic violence to keep the oil flowing. Deft negotiations with local political rivals and, in time, occupying foreign armies, enabled them to maintain a precarious hold on company property. But these efforts proved for naught. Facing the prospect of the petroleum industry's nationalization following the Bolsheviks' victory and the subsequent absorption of the Caucasus into a reconstituted "Red" empire, the last remaining company representatives escaped abroad. Branobel's storied history came to an abrupt end.

The challenges confronting Branobel's managers were hardly unique. Russia's "continuum of crisis" imposed terrible hardships throughout the empire. Educated specialists were particularly hard hit. Seeking escape from societal collapse, many with the means to do so emigrated abroad. Meanwhile, those specialists who chose (or were forced) to remain faced the prospect of death from starvation, disease, or widespread violence. Historians estimate that between 1917 and 1929 at least one-quarter of the nation's professors and instructors disappeared as a result of one cause or another.[4]

Existential threats to the livelihoods and lives of scientific and technical specialists (*spetsy*) alarmed the country's new revolutionary leaders. Keenly aware of the vital role these tsarist-era holdovers would play in the development of a future socialist state, Bolshevik Party officials instituted a range of special measures to forestall further losses of intellectual capital. James Andrews describes their efforts in his chapter, "Should I Stay or Should I Go?

[4] N. A. Grigor′ian, "'Utechki umov' iz Rossii v 1920-e i 1990-e gody: Sravnitel′no-istoricheskii analiz," in *Nauka i tekhnika v pervye desiatiletiia sovetskoi vlasti: Sotskul′turnoe izmerenie (1917–1940)*, ed. E. B. Muzrukovoi (Moscow: Academia, 2007), 410–33.

Russian Scientists, Relief/Aid Organizations, and Everyday Life (*Byt*) in War, Revolution, and Civil War, 1917–22."

The principal impetus for the formulation of policies to protect the *spetsy*, according to Andrews, came from Maksim Gor´kii, the famous working-class author and prewar advocate for technical literacy and public science. During the darkest days of the Civil War he led a grassroots effort to draw attention to the dangers facing technical specialists, academic researchers, and graduate students while mobilizing relief efforts on their behalf. His successful lobbying convinced Lenin and other influential Bolshevik officials to authorize, in December 1919, a supplemental "academic ration" (*uchenyi paek*) for those regarded as essential to the state's fortunes. The following month, Gor´kii's role as the chief intermediary between *spetsy* and the Party was institutionalized with his appointment as head of the newly established Central Commission for the Improvement of the Living Conditions of Scholars (Tsentral´naia komissiia po uluchsheniiu byta uchenykh, or TsEKUBU).

Ironically, Andrews notes, these measures effectively replicated the political patronage system that had shaped scientific and technical research under the tsars; TsEKUBU and other new Soviet institutions (most notably Glavnauka) adopted the sponsorship roles formerly played by imperial ministries. All the same, the relief granted by the Bolsheviks proved vital. Thousands of lives were saved and, with them, important scientific knowledge and technical experience that would contribute to the country's reconstruction.

These measures, however, were not without controversy. New working-class members who had flocked to the Bolshevik Party in the aftermath of October 1917 were incensed. Expanded rations, additional living space, and other privileges granted to technical specialists seemed to fly in the face of the Bolsheviks' stated promise of a classless society based on equality of conditions and workers' control of production. Specialists found themselves in a highly tenuous political position. The resolution of this issue would come at the end of the 1920s when prominent *spetsy* were made targets of the public show trials and murderous purges that marked the onset of the Stalinist era.

Viktoriia Kugai offers readers an individual account of the trials and tribulations that befell tsarist-era *spetsy* under Bolshevik rule in her chapter, "Two Lives in One Country: The 'Bourgeois Specialist' Engineer G. O. Graftio Serving the Dictatorship of the Proletariat." Virtually unknown among nonspecialist Western audiences, Genrikh Osipovich Graftio was one of the most gifted and versatile technical specialists to emerge from autocratic Russia's educational system. Born into the profession as the son of a railroad engineer, the younger Graftio followed in his father's footsteps while distinguishing himself as one of very few contemporary Russian engineers working in the nascent field of electric traction on railroads. His extensive work in the Pol-

ish territories and frequent research trips to Western Europe and the United States during the late 1880s and 1890s quickly made him one of the Russian Empire's leading experts in the field.

No less significantly, Graftio's work on electric traction led him to develop interest in the principal means intended to power the locomotives: hydroelectric generation. During the decade or so prior to the war, he participated in multiple commissions and projects devoted to Russia's electrification before taking up a position in 1912 as a government inspector overseeing construction of the Oranienbaum railroad—the first electrified passenger railroad in Russia. Although progress on this project came to a virtual standstill after the outbreak of hostilities in 1914, Graftio's subsequent work for the short-lived Provisional Government on the proposed Volkhov River hydroelectric plant brought him to the attention of the country's new Bolshevik regime.

Amid the myriad challenges that Bolshevik leaders faced in their effort to "build socialism" after October 1917, energy production and distribution loomed large. Lenin's personal faith in electricity's transformative potential to resolve once and for all the widespread fuel crises plaguing Russian cities and industries led him to champion GOELRO—a grandiose, technocratic plan to "enlighten" the country (both literally and figuratively) through a complex system of electrical generating stations, substations, and transmission networks. In almost every respect, GOELRO foreshadowed the even more grandiose projects of Stalin's Five-Year Plans. As Kugai recounts, Graftio played a foundational role in GOELRO's progress. Recruited by the Bolshevik state to participate in the project, he successfully overcame professional rivals and political threats to bring into the world GOELRO's "first born," the Volkhov hydroelectric station which, to this day, helps power St. Petersburg and its environs.

Graftio's success, according to Kugai, resulted from his consummate professionalism and avoidance of politics. Like his contemporary Maksim Gor´kii, he also benefitted from the patronage of top Bolshevik Party officials. On more than one occasion, Lenin's personal intercession secured Graftio's fortunes. Perhaps his most stunning achievement, however, was to survive the Stalinist-era repressions that later claimed the lives of so many of his colleagues. In these regards, his professional life testifies to the continuities that joined Russia's pre- and postrevolutionary eras as well as the significance that luck and happenstance often play in the history of technology and science.

Bourgeois *spetsy* like Genrikh Graftio were not the only experts who contributed to Russia's postwar technological culture. As the Civil War wound down, Bolshevik leaders looked to recruit foreign engineers and specialists to aid their quest to build a modern industrialized civilization. Many of these were enjoined to the cause through lucrative state contracts; others, drawn

from the ranks of leftist sympathizers and true believers, volunteered their services in the hope of hastening the advent of socialism. Journeying to and from the "Land of the Soviets," these fellow travelers facilitated the transmission of technical and political ideas between Russia and the West.

Maria Fedorova's chapter, "American Tractors, Soviet Soil: Agricultural Reconstruction and US-Soviet Technology Transfer, 1921–1923" examines the efforts undertaken by one such idealist, Harold Ware, to help modernize Soviet agriculture. A college-educated "red diaper baby" whose mother (like himself) was an active member of the Communist Party of America (CPA), Ware cut his teeth in the 1910s as a radical farm labor activist publishing and agitating on behalf of downtrodden agricultural workers. In 1921, at Lenin's behest, the CPA dispatched Ware on a cross-country research trip to gather information on the status of American farmers. His subsequent report helped convince the Bolshevik leader that the importation of American machinery, specifically tractors, was the key to helping improve Russia's agricultural production and forge a "united socialist front" between city and village. In the spring of the following year, Ware led a delegation to the Soviet Republic accompanied by $50,000 worth of tractors, agricultural equipment, and spare parts purchased by "Friends of Soviet Russia," a communist-front organization which had raised money to provide famine relief for the country's beleaguered peasantry.

As Fedorova describes, the humanitarian-support mission did not unfold as expected. Rather than being sent to the famine-stricken wheat-growing region along the Volga, Ware's embassy was ordered to Toikino, an isolated village 1,000 miles east of Moscow, where the continental climate, short growing seasons, and heavy clays soils were ill-suited to the Americans' machinery and methods. Political calculations had trumped agricultural needs; party leaders looked to use the tractors as gifts to win over the region's inhabitants to the Bolshevik cause. Nevertheless, Ware and his associates embraced their venue. Over the course of the 1922 growing season they organized demonstrations, delivered speeches, and trained local inhabitants on American agricultural practices and the operation of the tractors. In the process, the Americans' perceptions of the "backward" peasant masses changed markedly for the better; Soviet agriculture did not. Facing pushback from local agronomists who argued the foreigners' approach failed to account for the region's particular political, social, and climactic contexts, and hamstrung by the competing agendas and infighting of local administrators and Moscow authorities, Ware's unit departed the country never to return. In short order, the tractor unit was disbanded; the machinery left behind by the Americans soon disappeared from the historical record.

The center-periphery relationships that serve as backdrop to Fedorova's account of the Toikino tractor experiment function as a thematic leitmotif for Sofia Gavrilova's chapter, "War, Revolution, and the Production of Scientific Knowledge about the Periphery: The Emergence of the Soviet Kraevedenie Project." A distinctive Soviet field of inquiry devoted to the collection and interpretation of environmental, cultural, and economic data in regions beyond the country's major urban centers, *kraevedenie* traces its origins to the late 18th-century establishment of local museums by marginalized and, in some cases, exiled members of Russia's nascent scientific intelligentsia. Fueled by the concomitant growth of educational and scientific institutions (as well as the expansion of civic society) that accompanied the autocracy's modernization programs, *kraevedenie* expanded apace during the 19th century. By the eve of the Great War, Imperial Russia possessed some 300 societies and upwards of 90 museums devoted to studying and curating local lore.

As Gavrilova explains, the growth of *kraevedcheskie* organizations was accompanied by the conceptual transformation of *kraevedenie* practice as increasingly well-trained provincial professionals, working in collaboration with central institutions such as Moscow's Society of Lovers of Natural Science, Anthropology, and Ethnography, gradually discarded "classical" approaches emphasizing collection and preservation in favor of scientifically informed methodologies centered on the accumulation of data and statistical analysis. This academically grounded collaboration between center and periphery set the stage for the formal establishment of the field at the First All-Russian Conference of Scientific Societies for Studying Local *Krai* in 1921 and, thereafter, the rapid expansion of *kraevedenie* to virtually every corner of Soviet territory. Characterized by theoretically diverse viewpoints, relative autonomy, and agendas emphasizing local concerns, the "golden age" of *kraevedenie* would last until the late 1920s when it (and many of its leading figures) fell victim to the hypercentralization and political repression that accompanied the launch of the Cultural Revolution.

The final essay in Part 1 of this volume shifts focus away from technological developments towards an epochal transformation in scientific understanding that emerged amid the decade-long dislocation, disruption, and disintegration of 1915–25. In "Space-Time, Death-Resurrection, and the Russian Revolution," Alexei Kojevnikov postulates that the wide-ranging efforts of Russian artists and intellectuals to derive meaning from the cataclysmic shocks they had experienced inspired the formulation of an innovative theoretical model regarding the origins and nature of the universe.

Developed in response to Einstein's general theory of relativity by the brilliant Petrograd mathematician Alexander Friedmann (1888–1925), the new model postulated that the cosmos had exploded into being out of a singularity

a dozen or so billion years ago. In the eons that have passed since this moment of creation, Friedmann theorized, the cosmos was continuing to unfold in accordance with one of two mathematically possible formulae: outward expansion towards infinity, or expansion followed by ultimate collapse back into a singularity after billions of years.

Intriguingly, Kojevnikov notes, Friedmann also held out a third possibility, one that "reflected the mentality of a generation that lived through … the tragedy of millions of deaths, the collapse of the existing world order, the excitement and anxiety about the radically new, emergent world, and the hope for revival." Following collapse, the process of explosive outward expansion and contraction would repeat *ad infinatum* in an oscillating fashion which resembled the eternal cycle of death and resurrection articulated in public discourse by contemporary theosophists, certain avant-garde artists, and other mystically inclined thinkers such as Nikolai Fedorovich Fedorov, Konstantin Eduardovich Tsiolkovskii, and Petr Dem´ianovich Uspenskii (to name but a few).

Although further elaboration of Friedmann's ideas was prevented by his premature death from typhus at the age of 37, subsequent discoveries by British astronomer Edwin Hubble provided empirical evidence that posthumously validated his vision of a nonstatic universe. By the early 1930s none other than Albert Einstein had come to recognize the Russian mathematician as the first individual to articulate what is known today as the "Big Bang Theory" origins of the space-time continuum.

Part 2: "Environment"

In addition to the aforementioned chapters exploring the intersections of technology, science, politics, and culture, the current volume provides readers with new research and insights into the many ways in which environmental factors both shaped and were shaped by the experiences of war, revolution, and civil war.

Tony Heywood's chapter, "Climate, Weather, and Tsarist Russia's Great War, 1914–1917: The Wartime Winters," leads off the environmentally themed essays with a detailed examination of the impact that climactic patterns played on the conduct of the war. Drawing primarily upon air temperature and precipitation data compiled by the Russian Empire's principal meteorological center, the Nicholas Main Physical Observatory (Nikolaevskaia Glavnaia Fizicheskaia Observatoriia), Heywood reconstructs the general conditions that contemporaries faced during the three-plus years in which Russian armies undertook operations against the Central Powers. His findings serve as an important corrective to popular notions of combat in Russia

shaped by the disastrous experiences of the Napoleonic (1812/13) and Nazi (1941/42) armies.

As Heywood notes, European Russia's weather patterns are products of its continental climate which is characterized by significant temperature variations that produce both the country's stereotypically very cold winters but also warm to hot summers. The vast size of the region, however, ensures that conditions may differ (sometimes dramatically) from one location to another during the same season. Well familiar with their surrounding environment, imperial military planners had long since adapted their mobilization schedules and strategic plans to account for expected conditions. Still, they faced daunting obstacles. Thanks to a woefully underdeveloped transportation network relative to the empire's size, even "normal" weather conditions posed seasonal challenges to waging war.

Summer was obviously the best season for moving men at arms, but summertime mobilization was most disruptive to the economy as it pulled laborers away from the essential task of bringing in the harvest. Summer could also pose significant transportation challenges when low water levels on Russia's gently flowing, meandering rivers made it impossible for barges to move heavy loads through shallows. Spring and fall also presented problems; both were accompanied by *rasputitsa*, the biannual period when snow melt and heavy rains, respectively, disrupted river traffic, washed out bridges, and turned the country's unpaved roads into impassable mire. While exceptionally harsh winters (such as those of 1812/13 and 1941/42) posed considerable challenges for all armies, so, too, did comparatively warm ones. The advantages derived from employing horse-drawn sleds to facilitate movement across hard, frozen ground were quickly lost when early or brief mid-winter thaws replicated the muck and mire associated with *rasputitsa*.

Although the wartime weather experienced on the Russian front during 1914–17 produced nothing like the historically bitter conditions delivered by "General Frost" in 1812/13 and 1941/42, as Heywood convincingly demonstrates, even climactic patterns well within the mean posed significant challenges to military and civilian planners alike.

Where Heywood's chapter lends important insight into the essential, yet complex, role that environmental factors played in shaping wartime experiences writ large, the volume's subsequent two entries, "Embattled Nature: Men and Landscapes on the Eastern Front of the First World War" by Oksana Nagornaia and Iaroslav Golubinov, and "Mobilization and Ecology in the Russian Theater of War (1914–1917)" by Aleksandr Astashov, address the opposite side of the equation—the impact of military operations on the frontline environment. The chapters call to mind well-known images of the incredible wartime devastation perpetrated along the Western Front in France, Belgium,

and Germany. Though less familiar to most readers, military operations in the East likewise generated an elaborate system of earthen fortifications and trenches, intensive artillery bombardments, and large-scale maneuvers that destroyed local towns and villages, displaced inhabitants, and rendered once fertile agricultural farmland unfit for cultivation. While these activities damaged the environment in similar ways along the different fronts, the extensive scale of operations in the East meant that the impact of industrialized warfare affected far more territory and many more lives.

Both chapters explore the ways in which wartime events transformed Russians' attitudes toward the natural world and its resources. Nagornaia and Golubinov do so through a personalized view of human encounters and attitudes toward the wartime environment. Drawing upon correspondence, diaries, and memoirs, the authors chronicle how the perceptions of frontline combatants and military planners evolved as a result of their interactions with challenging wartime landscapes and the technologies employed to overcome those environmental challenges. Meanwhile, the complimentary chapter by Astashov considers three case studies: plans to undertake the defensive flooding of reclaimed agricultural lands; the management of woodland timber resources; and efforts to stem the spread of contagious disease. He concludes that environmental crises born of the conflict led military authorities and civilian representatives to develop new strategies for resource management that served as foundations for postwar conservation efforts.

Tamara Polyakova, by contrast, uses a regional approach focused on Russian Karelia for chronicling the complex ways humans adapted to environmental extremes during the Civil War. Her chapter, "Environment and Warfare in the Russian Civil War: Nature as an Enemy in Karelia," shows how the difficult and oftentimes inhospitable climate imposed considerable challenges on the soldiers and civilians who found themselves dispatched to the resource-rich region. Spellbindingly beautiful landscapes coupled with dark and bone-chilling winters inspired the men stationed there even as they threatened their mental health and physical wellbeing. These experiences, Polyakova ultimately concludes, shaped subsequent Soviet attitudes towards the region and its resources as state officials looked to bend the environment to their grand designs by cultivating the region after the fashion of a garden.

Natural landscapes were not the only environmental settings with which combatants and civilians were forced to contend. As Dmitrii Ivanov demonstrates in "Environmental Impacts of Industrial Warfare and the Russian Revolution, 1914–1920: 'Producing Death' at the Shlissel´burg Gunpowder Works," industrial landscapes constituted another significant, if understudied, site of human-environmental interaction.

Founded by the Russian Society for Production and Sale of Gunpowder in the mid-1880s at the head of the Neva River on Lake Ladoga 35 miles east of St. Petersburg, the Shlissel´burg Gunpowder Works soon grew to become Russia's largest privately owned explosive production facility. By 1909, the manufacturing complex comprised 371 buildings, including workshops, power plants, barracks, and churches, spread out across seven square miles of territory connected by 22 miles of railway tracks. The dispersed layout, similar to enterprises in Germany, the United States, and elsewhere, was designed to provide a degree of security from the ever-present threats posed by stores of toxic chemicals, live ordnance testing, and the inevitability of accidental explosions.

Not surprisingly, the onset of war in 1914 led to the tremendous expansion of the Gunpowder Works. In very short order, a wide range of new chemical compounds were added to the facility's regular menu which included gunpowder, trinitrotoluene, tetryl, dynamite, and sulfuric and nitric acids. The proliferation of products was matched by incredible growth in the scope of operations. Between 1914 and 1917 the size of the workforce increased more than tenfold. As the company's owners scrambled to reach production in scale as quickly as possible, labor and living conditions at the industrial complex, which were already quite poor, grew significantly worse. Temporary housing and storage facilities were quickly cobbled together using slapdash construction methods; these afforded workers little comfort and even fewer protections from the range of noxious compounds with which they worked. Food and medical shortages became commonplace. Declining sanitation standards contributed to the spread of infectious diseases. The frequency and severity of accidents grew apace. By 1915, even the healthiest workers at the facility were physically broken within a few years of beginning employment.

The result, according to Ivanov, was the emergence of a "militarized industrial landscape" every bit as threatening to humans and nature as the industrialized warfare taking place on the frontlines. While abysmal conditions and the ready availability of alcohol (used in the production of smokeless gunpowder) transformed the factory into a site of revolutionary resistance to the Provisional Government, the nationalization of the complex that followed the Bolshevik takeover did little to improve the situation. Egged on by Lenin, an abortive effort to transform the Gunpowder Works into a site for the production of "grape sugar," an *ersatz* alcohol derived from sawdust and sulfuric acid, proved more symbolic than substantive. All the same, given the centrality of the complex to the state's industrial-military fortunes, operations would continue. In hindsight, the terrible costs associated with the Gunpowder Works' "militarized industrial landscape" foreshadowed the environmental

degradation and human suffering that became commonplace following the onset of Stalinist industrialization.

Human-environmental encounters during the Great War and revolutions were not, of course, limited to the heartland of the former Russian Empire and future Soviet Union. They unfolded across Eurasia, often with devastating results for both local inhabitants and landscapes, as Jennifer Keating demonstrates in her contribution to the volume, "Environmental Perspectives on Social Unrest and Economic Collapse in Turkestan, 1916–1919."

Annexed by the tsarist government during the 1860s, the Central Asian region of Turkestan quickly became a focus for Russian economic planners who looked to transform its central and southern territories into a cotton monoculture that could supply raw materials to Moscow's expanding textile industries. To sustain the new settlements that would accompany population growth, they simultaneously introduced the cultivation of cereal crops, fruits, and vegetables to Turkestan's fertile northern lands. In the years that followed, the gradual importation of intensive agricultural methods, along with the arrival of tens of thousands of ethnic Russian colonists, contributed to escalating friction between these new arrivals and the indigenous Kazakhs and Kirgiz whose traditional nomadic livelihoods and cultures were displaced by the influx of foreign methods and technologies.

Longstanding tensions between Turkestan's competing ethnic and political factions erupted in 1916 at the height of the Great War. Widespread violence quickly engulfed the region as Muslims, non-Muslims, pro- and anti-Bolshevik forces, Russian settlers, and extrastate actors fought against one another in a series of complex and constantly shifting alliances that brought chaos to the region. The "continuum of crisis" laid waste to both the landscape and lives before a semblance of order was restored in 1919–20 by Red Army units under the command of Mikhail Vasil'evich Frunze.

While the complex story of the Turkestan uprising has been the subject of scholarly inquiry, Keating provides new insight by underscoring the central role the natural and built environments played in the unfolding disaster. Noting, as have others, that the revolt was born from disputes over arable land, Keating avers that once underway, natural resources and the technologies used to secure them "became the fulcrum around which violence emanated." In the process of settling scores and attempting to reclaim the landscape, indigenous rebels targeted Russian peasants' livelihoods. They seized property and livestock, burned villages, and laid waste to crops in fields and orchards; their adversaries reciprocated in kind. As anarchy descended, rebel factions turned their attention to the technological infrastructures that facilitated imperial control, destroying railroads, bridges, telegraph lines, and even hydro-

metric stations in an effort to disrupt communications and forestall the arrival of reinforcements.

Given colonial Turkestan's dependence on the importation of manufactured goods and basic foodstuffs to sustain its inhabitants, the destruction visited upon these elements of the built environment proved catastrophic to all. Cut off from contact with the outside world and suffering from lost harvests and ravaged pasture lands, the region's inhabitants endured food shortages, hunger, then widespread famine and the inevitable rampant spread of disease. These by-products of armed conflict took the lives of between one and two million souls before the Bolsheviks finally secured control, only to restore the antebellum cotton monoculture, albeit at a significantly reduced productive capacity.

Part 3: "Medicine"

The demographic catastrophe that unfolded in Turkestan between 1916 and 1919 was typical of the broader patterns of death and destruction visited upon Eurasian populations during the Civil War. Throughout the period, the numbers of lives lost to direct military action paled in comparison to the devastation caused by famine and infectious diseases. While the latter was kept largely in check by imperial agents before 1917, the roiling chaos that followed the onset of the Civil War in 1918 unleashed repeated waves of smallpox, cholera, dysentery, malaria, and, above all, typhus that would claim millions more lives than those lost in military operations.

As David R. Stone observes in "The Red Army and Epidemic Disease in the Russian Civil War," Bolshevik leaders struggled mightily to combat the spread of these contagions. Unable to implement traditional treatments such as mass vaccinations owing to severe shortages of trained personnel, equipment, and medical supplies, Lenin's government adopted an *ad hoc* strategy that combined ideological exhortations and mass mobilization to educate individuals about the imperatives of personal cleanliness and basic sanitation. At the same time, it looked to counteract the spread of disease by establishing "isolation points" at key railroad junctions to identify and detain those who had fallen ill, fumigate railroad cars, and disinfect travelers and their clothing.

Ironically, Stone notes, the institution principally charged with implementing these measures, the Red Army, was also the principal vector for the transmission of epidemic diseases. Large numbers of men travelling and living in crowded, unsanitary conditions provided ideal breeding grounds for deadly contagions. Time and again, the state's military leadership found themselves reissuing directives to their subordinates demanding they follow basic sanitation protocols including screening for sickness, boiling water, and

properly disposing of human waste. In the meantime, they sought to maximize the impact of the country's meager vaccination supplies by restricting their use to important links in the disease chain such as public health workers, food service providers, and water resource personnel. By 1923, the combination of rhetoric and restrictions on movement had reduced outbreaks to more manageable levels. Public infection rates remained exceedingly high (relative to the pre-1914 peacetime baseline) for years to come, but by the mid-1920s the country had turned the corner. At this point, the state and military turned to implementing health policies "more or less indistinguishable from traditional armies" with a particular emphasis on combating that most traditional of all military afflictions: venereal disease.

In the final contribution to the volume, Evgenii Naumov provides further insight into the military's battle against infectious disease in a chapter titled "The Military Context of Bolshevik Health Practices: The Red Army on Its Eastern Front in 1918." Focusing on the critical second half of 1918, when Red Army commanders began in earnest to address the major problems confronting the young Bolshevik state, Naumov argues that organizational confusion and military-civilian infighting as well as the individual choices made by personnel hampered initiatives to stem the growing public health crises. In support of his position, Naumov draws upon a wide array of largely overlooked materials including deployment orders, clerical and bureaucratic reports, memoirs, and notes which suggest that the spread of disease during the Civil War owed at least as much, if not more, to the actions undertaken by military and medical personnel. In doing so, Naumov's chapter departs from established scholarly interpretations which have emphasized the meagre resources bequeathed to the Bolsheviks as the chief obstacle to effective public health measures.

In sum, the chapters contained in this volume provide a wide array of investigative resources and thematic leads for scholars and general readers interested in the complex transformations occasioned by Russia's Great War and Revolution. No less significantly, by drawing attention to the understudied fields of Russian science, technology, environment, and medicine, they shed new light on longstanding historiographical debates regarding the country's path to modernization; the contributions of its technical and scientific experts; and the extent to which the institutions and methods adopted by Soviet leaders were built upon foundations established by their imperial predecessors. Taken as a whole, the collection constitutes a significant contribution to multiple fields of inquiry; its authors' findings and perspectives can be expected to influence scholarly agendas and understanding for years to come.