

Parallel Worlds: Formal Structures and Informal Mechanisms of Postwar Soviet Mathematics

Slava GEROVITCH*

Abstract

The postwar period is often viewed as the “Golden Age” of Soviet mathematics, yet the mathematical community in that period faced serious constraints. Restrictions on foreign travel, limited access to foreign literature, obsessive secrecy regulations, an obsolete university curriculum, the declining level of the faculty, discriminatory policies in university admissions and employment, and limitations on physical access to universities and research institutions—all these factors worked against the creation of a fully functional research community. This article argues that the thriving of Soviet mathematics in that period was due to the creation of a parallel social infrastructure. Soviet mathematicians organized a network of study groups (“math circles”), correspondence courses, and specialized mathematical schools in major cities, opened free courses for students barred from top universities, offered employment at applied mathematics institutions to talented researchers who were denied academic positions, and developed an extensive system of open research seminars, bringing together multigenerational groups of researchers and fostering collaboration and the spread of new ideas.

Key words: Soviet Union, mathematics, education, politics, discrimination

The game approach to problem-solving allows us to do things
that cannot be fully analyzed by formal means.

Israel Gelfand¹

A “Golden Age”?

The period from the 1950s through the early 1980s is fondly remembered by Russian mathematicians as the “Golden Age” of Soviet mathematics.² “Golden ages” usually have little to do with the actual achievements of the past; they rather reflect the frustrations and

* Massachusetts Institute of Technology, Cambridge, Mass., U.S.A.

¹ “Protokol zasedaniya Uchenogo soveta OPM MIAN,” June 28, 1960; Archive of the Russian Academy of Sciences, Moscow (hereafter ARAN), f. 1939, op. 1, d. 20, l. 38.

² Smilka Zdravkovska and Peter L. Duren, eds., *Golden Years of Moscow Mathematics* (Providence, RI: The American Mathematical Society, 1993).

failed hopes of the present projected onto the past. Yet, without idealizing this period, it is worth examining what was so unusual about it that made it possible to construct its image in collective memory as a “Golden Age.”

Historians of science have traditionally explained the thriving of mathematics in the Soviet Union by its attractiveness to talented youth who could achieve success in this field by relying solely on their own efforts. Mathematics was viewed as a discipline free from the ideological pressures characteristic of research in the social and biological sciences. Loren Graham, for example, has argued, “Gifted young people gravitated to fields where achievement was possible despite the political and economic barriers of tsarist Russia and the Soviet Union.”³ The so-called “blackboard rule” is also often evoked to explain why Russian scholars excelled in fields in which minimal resources, such as blackboard and chalk, would suffice, and which, therefore, were not heavily dependent on government support. The phrase “blackboard rule” was coined by Thane Gustafson, who has argued that “Soviet pure science is strongest in fields that depend the least on material support,” most notably, in mathematics.⁴ Such explanations, however, raise the question whether a concentration of talent and the simplicity of research tools are sufficient to produce good scholarship. If mathematics is viewed as an activity of the mathematical community, rather than an individual pursuit, then a crucial component must be the social infrastructure that supports research: a social space where scholars can meet and discuss their research, publishing outlets for the dissemination of results, and the freedom to put forward innovative ideas.

An examination of the actual conditions in which Soviet mathematics was practiced at the time reveals a paradoxical situation. Soviet mathematics in its official settings faced serious obstacles in all three aspects of the social infrastructure. Mathematical institutions and discursive norms were anything but conducive to productive research. This paper will focus specifically on the problems typical of the postwar period and on some strategies of Soviet mathematicians to circumvent those barriers.

Travel restrictions: Limiting international contacts

In general terms, Soviet mathematics in the postwar period could be viewed as confined in a restricted space. It was restricted in several aspects: geographical, conceptual, administrative, and even physical. The situation evolved over the course of forty years, of

³ Loren R. Graham, *Science in Russia and the Soviet Union: A Short History* (Cambridge, UK: Cambridge University Press, 1993), p. 201. Interestingly, in the 19th century Russian radical youth looked down on mathematics precisely because of its stereotypical image as an aloof discipline standing above social concerns. According to Alexander Vucinich, “Because mathematics was cold, logically involved, and ideologically neutral, it was not especially attractive to the growing ranks of science enthusiasts in Russia”; *Science in Russian Culture: 1861–1917* (Stanford, Calif.: Stanford University Press, 1970), p. 166.

⁴ Thane Gustafson, “Why Doesn’t Soviet Science Do Better Than It Does?,” in Linda L. Lubrano and Susan Gross Solomon, eds., *The Social Context of Soviet Science* (Boulder, Co.: Westview Press, 1980), p. 32. Alexander Vucinich also argued that physiology developed more slowly than mathematics in 19th-century Russia because “mathematics required no expensive laboratories, whereas modern physiology was impossible without them”; *Science in Russian Culture: A History to 1860* (Stanford, Calif.: Stanford University Press, 1963), p. 338. See also Graham, *Science in Russia and the Soviet Union*, p. 207.

course, and this picture would be an unavoidable oversimplification.

First, Soviet mathematicians had relatively weak ties with the international community. Foreign travel was severely limited. In the late Stalinist period, at the height of the ideological campaign against “cosmopolitanism,” Soviet academics had to avoid any scholarly contacts with foreigners to evade the accusation of “kow-towing” before the West. In 1950, the Soviet Academy of Sciences declined an invitation to the International Congress of Mathematicians in Cambridge, UK, on the pretext that “Soviet mathematicians are too busy with their routine work and cannot attend the congress.”⁵ Starting in 1954, Soviet delegations began attending the congresses, but the delegation membership was tightly controlled by the Soviet authorities. Junior mathematicians and those who made political transgressions could not travel at all, and even leading mathematicians personally invited to give a talk at international congresses were often barred from attending them. For example, the corresponding member of the Academy of Sciences Israel Gelfand was not allowed to travel to the 1954 Congress in Amsterdam; someone else presented his paper. At the last moment the Soviets included another mathematician in their delegation, even though he did not present a paper.⁶ Although repeatedly invited to international congresses, Gelfand did not attend any congresses held abroad until the 1980s. The mathematician Mstislav Keldysh, president of the Soviet Academy of Sciences in 1961–1975, reportedly commented, “The harm from not letting Gelfand go abroad has already succeeded any potential harm from letting him go.”⁷

Access to foreign books and journals was also limited. Translated volumes were printed in small runs and quickly sold out. Obtaining them through second-hand bookstores was a matter of good luck. Citing foreign authors could be viewed as diminishing the contribution of Soviet mathematicians. Publishing in foreign journals required special permission and was often looked upon with suspicion as a sign of political disloyalty. When observing a rare instance of lively exchange with foreign scholars at an international conference, Gelfand once remarked, “Of course, we live in a prison.”⁸

Conceptual restrictions: Imposing a rigid curriculum

Although advanced by Western standards, the mathematics curriculum even at leading Soviet universities was very rigid and emphasized technical skill over conceptual depth. Under the Soviet educational model, all students were put through the same obligatory sequence of courses, often outdated. Because of political and ethnic purges conducted among the faculty, and the rigidity and conservatism of the educational system as a whole,

⁵ Michael Monastyrsky, *Modern Mathematics in the Light of the Fields Medals* (Wellesley, MA: A. K. Peters, 1998), p. 13.

⁶ P. S. Aleksandrov, “Otchet delegatsii AN SSSR na Mezhdunarodnom matematicheskom kongresse 1954 g.,” January 1955; ARAN, f. 471, op. 1, d. 97a, ll. 18–37.

⁷ Quoted in Vladimir Uspenskii, “Lermontov, Kolmogorov, zhenskaya logika i politkorrektnost’,” in *Trudy po NEmatematike*, vol. 2 (Moscow: OGI, 2002), p. 1223.

⁸ Quoted by Anatoly Vershik in Vladimir Retakh, ed., “Israel Moiseevich Gelfand, Part I,” *Notices of the AMS*, vol. 60, no. 1 (January 2013): 15.

a “dramatic decline” occurred in the quality of math teaching.⁹ Universities rarely if ever offered courses in new, booming research fields, such as algebraic topology.

The efforts to introduce new courses often faced resistance. A former Moscow University lecturer has remarked, “Much should be changed in teaching, but you can change almost nothing at the University. The University is an automatically moving machine. Professor Vladimir Mikhailovich Tikhomirov for 20 years tried to revise the course of analytical geometry at Moscow University’s Faculty of Mechanics and Mathematics, known as Mekhmat. Everybody agreed, yet the revision did not occur, because, they explained, one could not take a gear out of clockwork and replace it with a gear of a different size.”¹⁰

In the 1970s the efforts to expand the curriculum by inviting leading mathematicians from outside the University, working for little or not pay, to offer open seminars or specialized courses faced systematic opposition from the Mekhmat officials. Professor Feliks Berezin had to appeal to the University administration “to restore the long-held tradition that every actively working mathematician, even not a member of the faculty, may lead a special seminar or read a special course either without pay or for hourly rates.” He argued that “among the traditions of our Department, there has always been a very free atmosphere —*of active participation of mathematicians, who are not members of the faculty, possibility to lead seminars or specialized courses... The current Administration is the first to regulate such a practice, without, incidentally, coordinating this regulation in any way with the scientific value of the program or with the popularity among the students attending the special course or special seminar.”¹¹

Political restrictions: Barring the “undesirables”

Despite the limitations of their curriculum, the leading universities were still the best places to get education, for other institutions were even more limited in their offerings. Without access the elaborate system of fundamental lower-level courses of Mekhmat, “the road to professional mathematics was, if not totally closed, then at least greatly hampered.”¹²

In the early 1970s, however, the policy of admission to leading universities was drastically reconsidered and became heavily biased. Access to Moscow and Leningrad universities and a few other leading institutions of higher education was severely limited for the “undesirables”—groups which included the Jews, students suspected of political dissent, and sometimes, ironically, graduates of schools with advanced math instruction.¹³ Jewish

⁹ Andrei Zelevinsky, “Remembering Bella Abramovna,” in *You Failed Your Math Test, Comrade Einstein*, ed. Mikhail A. Shifman (Singapore: World Scientific, 2005), p. 192.

¹⁰ Nikolai Konstantinov, interview by Aleksandr Kostinskii, 2 June 2004, Radio Liberty (<http://www.svoboda.org/content/transcript/24197560.html>).

¹¹ Felix Berezin, “Letter to Academician R. V. Khokhlov, the Rector of the Moscow State University” (1977), in *Felix Berezin: The Life and Death of the Mastermind of Supermathematics*, ed. M. Shifman (Singapore: World Scientific, 2007), p. 240, 238.

¹² Zelevinsky, “Remembering Bella Abramovna,” p. 192.

¹³ Mikhail Tsfasman, “Sud’by matematiki v Rossii,” Lecture at Bilingua Café, Moscow, June 28, 2008 (<http://polit.ru/article/2009/01/30/matematika/>).

applicants were usually separated from the rest, hoarded in one room, and subjected to a grueling procedure of systematic elimination. They were given problems known as “killer” or “murderous” problems, which far exceeded in difficulty the problems given to the other applicants. According to many reports, “the students were given these problems one after another until they failed one of them, at which point they were given a failing mark.”¹⁴

The “killer” problems were comparable to the most difficult problems offered at All-Union Math Olympiads, and sometimes were directly borrowed from the Olympiads.¹⁵ In 1999, the prominent mathematician Ilan Vardi, then a visiting professor at Institut des Hautes Études Scientifiques in Bures-sur-Yvette, France, attempted to solve 25 “killer” problems. It took him six weeks of continuous work to solve the 25 problems; on average, more than a day and a half per problem.¹⁶ Very few Jewish applicants were able to survive the ordeal. Two Moscow mathematicians and human rights activists, Boris Kanevskii and Valerii Senderov, collected statistics about the discrimination of Jews during admissions exams to Mekhmat. The discrepancy in the admissions figures of Jewish and non-Jewish graduates of Moscow math schools is telling. In 1979, of the 40 Jewish applicants, among them 26 Olympiad winners, only 6 were admitted. Of the 47 non-Jewish applicants, among them 14 Olympiad winners, 40 were admitted.¹⁷ Kanevskii and Senderov termed such policies an “Intellectual Genocide.”¹⁸

As a result, the “undesirables” were often consigned to second-tier educational institutions and effectively barred from graduate school. For them, self-study was the only way to learn cutting-edge mathematics.

Administrative restrictions: Controlling the institutions

Repeating the general Soviet pattern of administration of teaching and research, Soviet mathematics had a rigid hierarchical organization. Directors of research institutions and heads of university departments wielded enormous administrative power over hiring and firing, giving or withholding permissions for foreign travel, and promotions. Several key institutions controlled everything—the Institute of Mathematics of the Soviet Academy of Sciences, which employed about 100 full-time researchers; the National Committee of Soviet Mathematicians, overseeing Soviet participation in international conferences and or-

¹⁴ Tanya Khovanova and Alexey Radul, “Jewish Problems,” October 18, 2011 (<http://arxiv.org/abs/1110.1556>), p. 2. For a detailed account by a student subjected to this procedure, see Edward Frenkel, “The Fifth problem: math & anti-Semitism in the Soviet Union,” *The New Criterion* 31 (October 2012): 4 (<http://www.newcriterion.com/articles.cfm/The-Fifth-problem-math—anti-Semitism-in-the-Soviet-Union-7446>).

¹⁵ A. Shen, “Entrance Examinations to the Mekh-mat,” *The Mathematical Intelligencer*, vol. 16, no. 4 (1994): 7.

¹⁶ Ilan Vardi, “My Role as an Outsider,” in *You Failed Your Math Test*, ed. Shifman, p. 105. In 1975 Valerii Senderov asked eight top math students in the country, who were at a summer camp preparing to represent the Soviet Union at the International Math Olympiad, to solve a set of “killer” problems. After a month, the eight students solved only half of the problems; Khovanova and Radul, “Jewish Problems,” p. 2.

¹⁷ Shen, “Entrance Examinations to the Mekh-mat,” p. 8.

¹⁸ B. Kanevsky and V. Senderov, “Intellectual Genocide,” in *You Failed Your Math Test*, ed. Shifman, pp. 110–133.

ganizations; the All-Union Certification Commission, which officially certified academic degrees; and the editorial boards of leading journals and publishing houses. The leadership of these institutions was in the hands of a select group of Party loyalists, who vigorously promoted their supporters, while placing barriers in the path of “undesirables.” Some administrators acted following hints or “signals” from above, others were motivated by personal hatred or anti-Semitic views. The mathematics community was thus split into “us” and “them”—those supporting the ruling clique and those opposing it. The clique systematically discriminated against their opponents. Even leading mathematicians who disagreed with these policies were not allowed to travel abroad, take graduate students, or hire bright young researchers, who fell under the rubric of “undesirables.”¹⁹

Discriminatory hiring policies effectively excluded the “undesirables” from mathematical research organizations. Several leading mathematicians had to work at non-academic institutions, pursuing pure mathematics as a hobby. Besides the strain on their time and finances, this also made it very difficult for them to publish their results. Most scholarly journals in the Soviet Union required certification that a submitted article did not contain classified information. One had to obtain a clearance certificate at one’s workplace, and “it was very difficult to get such a ‘certification’ for a person who was not an employee of an institution officially designated to carry out research in the given area.”²⁰

Informal interactions between professors and students were discouraged. In 1956 the leading mathematicians Pavel Aleksandrov nostalgically recalled the prewar years, when “students gathered in seminars, like Luzin’s seminar. . . A large group of students led by the head of the seminar formed a collective. . . Professors lived together with students in dormitories. Later this was stopped. The socialization between professors and students was discouraged. Student visits to professors’ homes, introduced by Professor D. F. Egorov, were not recommended. Instead, students were divided into groups.”²¹ The same year Aleksei Liapunov, professor of Moscow University and a researcher at the Institute of Applied Mathematics, was chastised by his fellow Communist Party members for organizing a home study group (on mathematical methods in biology): “The error of comrade Liapunov was that he has violated the Party ethics by holding meetings of a youth study group in his home, outside the control of political organizations,” such the Communist Party or the Communist Youth League.²²

¹⁹ For example, Vladimir Arnold, an invited speaker at the 1983 International Congress in Warsaw, was not allowed to attend; Vladimir Rokhlin, who over 20 years advised a large number of outstanding students at Leningrad University, was reportedly unable to hire any of them; see A. Vershik, “Science and Totalitarianism,” in *You Failed Your Math Test*, ed. Shifman, pp. 145–147.

²⁰ *Ibid.*, p. 148.

²¹ Stenogramma obshchego sobraniya professorov MGU, 26 October 1956; Central Municipal Archive of Moscow, f. 1609, op. 2, d. 415, l. 19. On the rich tradition of informal interactions between the leading mathematicians of the Moscow school of mathematics Dmitrii Egorov and Nikolai Luzin and their students, including Pavel Aleksandrov, see Loren Graham and Jean-Michel Kantor, *Naming Infinity: A True Story of Religious Mysticism and Mathematical Creativity* (Cambridge, MA: Belknap Press of Harvard University Press, 2009).

²² Mstislav Keldysh, in Protokol №7 zasedaniya partiinogo biuro Otdeleniya prikladnoi matematiki, September 27, 1956; Central Archive of Social Movements of Moscow, f. 8033, op. 1, d. 3, l. 63.

Physical restrictions: Building fences

Exchange of ideas in the mathematics community was hampered by the physical isolation of leading institutions. Physical access to research institutions and universities was limited to the members of these institutions; the territory was often fenced and guarded; outsiders had to obtain temporary passes, which was often difficult if not impossible. Moscow University, for example, was surrounded by a formidable fence. A guard at the entrance booth was checking IDs and turning away anyone not affiliated with Moscow University.

Resourceful visitors invented many creative ways of circumventing the guards. Effective strategies included: presumption (busily walking through with an indifferent air), substitution (flashing a similarly-looking ID card from another institution), and brute force (plainly climbing the fence). Even foreign visitors had to be “smuggled” into Moscow University to pass the guards.²³ The audience of mathematical events was therefore self-selected for creativity.

All these factors worked against the creation of a fully functional mathematical community. In other words, the conditions in which Soviet mathematics developed in the 1950s-80s looked like a recipe for disaster, not for a “golden age.”

A parallel social infrastructure

Moscow University, the citadel of Soviet higher education, epitomized all these restrictions. This building, a Stalin-era 36-story Baroque/Gothic skyscraper on Sparrow Hills, thrust its pointed top 240 meters high, remaining the tallest building in Europe until 1990. It apparently symbolized the Soviet students’ unstoppable quest for knowledge, but its Faculty of Mechanics and Mathematics, the largest and most revered mathematics department in the Soviet Union, effectively enforced all the restrictions outlined above.

Yet it was precisely at Moscow University that Soviet mathematicians developed practices that undermined these policies and made Soviet mathematics the envy of the world. The thriving of Soviet mathematics in this period was due to the creation of a parallel social infrastructure, which existed apart from and in some sense in opposition to the official institutions.

Soviet mathematicians developed a number of strategies to overcome the restrictions faced by the mathematics community. They organized a network of study groups (“math circles”), correspondence courses, and specialized mathematical schools in Moscow and other major cities, selecting talented high school students and giving them instruction at an advanced level. Math Olympiads and other competitions proliferated, providing opportunities for “undesirables” to gain access to leading universities. Free evening courses were open to students who were barred from top educational institutions. Employment at computer centers and applied mathematics institutions was offered to “undesirables” who could not be employed as mathematics researchers. Finally, an extensive system of open

²³ Pierre Deligne, interview by Robert MacPherson, May 14, 2011 (http://simonsfoundation.org/science_lives_video/pierre-deligne/), part 17.

research seminars brought together multigenerational groups of researchers and fostered collaboration and the spread of new ideas.

Math schools

As a result of academic mathematicians' efforts, in the 1960s a network of specialized mathematical schools emerged in major Soviet cities. Several mathematicians, involved in the nuclear weapons program, used the authority they gained from this high-priority work to advance their own agenda of improving mathematical education in select schools. Citing the Soviet military's growing demand for computer programmers, they took advantage of Khrushchev's ongoing reform of school education. To address the shortage of qualified workforce, in late 1958 the Soviet school system was reorganized. Obligatory training in various industrial professions was introduced in high schools. Mathematicians and physicists quickly realized that they could make this reform serve their own needs. The leading nuclear physicists Andrei Sakharov and Iakov Zel'dovich publicly called from the pages of the Party mouthpiece *Pravda* to establish specialized math and physics schools.²⁴ The prominent mathematicians Andrei Kolmogorov and Mikhail Lavrent'ev also added their voices.²⁵

While prominent scientists were lobbying the government, ordinary mathematicians and physicists developed local initiatives. Under the banner of preparing computer programmers, they began organizing specialized high schools with advanced instruction in mathematics and physics without any order from above. In 1958 Moscow School #2 organized computer programming courses with the support of the Institute of Precise Mechanics and Computer Technology, which was located across the street.²⁶ In 1959 Semyon Shvartsburd, a leading specialist in mathematical education, introduced computer programming at School #444, and then developed advanced mathematics curriculum, adopted in many other schools.²⁷ In 1961, mathematician Aleksandr Kronrod from the Institute of Theoretical and Experimental Physics organized a specialized class for mathematics and computer programming at School #7 in Moscow and began teaching there himself.²⁸ His graduate student Nikolai Konstantinov also taught at the school and later organized math classes in Moscow schools #57 and #179. The large number of Jewish students enrolled in School #7 alarmed local Party authorities, and the school administration was forced to limit the admission of Jews. Among others, they turned away the son of Israel Gelfand. Gelfand, who had been responsible for crucial calculations for the hydrogen bomb at the

²⁴ Ia. Zel'dovich and A. Sakharov, "Nuzhny estestvenno-matematicheskie shkoly," *Pravda* (19 November 1958), reprinted in A. M. Abramov, *Kikoin. Kolmogorov. FMSH MGU*, 2nd ed. (Moscow: Fazis, 2008), pp. 111–113.

²⁵ Abramov, *Kikoin. Kolmogorov. FMSH MGU*, pp. 115–131.

²⁶ Georgii Efremov and Aleksandr Koval'dzhi, comps., *Zapiski o Vtoroi shkole*, 2nd ed. (Moscow: Novosti, 2006) (<http://ilib.mccme.ru/2/>).

²⁷ E. Dynkin, et al., comps., *Matematicheskaya shkola. Lektsii i zadachi*, vyp. VI (Moscow: Moscow University, 1965), pp. 63–68.

²⁸ V. M. Tikhomirov, "A. S. Kronrod (1921–1986)," *Matematicheskoe prosveshchenie*, series 3, no. 2 (2006): 49–54.

Institute of Applied Mathematics, quickly found a solution: he enrolled his son in School #2 and made arrangements to establish a mathematical class there, in exchange for his own teaching in the school. Professor of Moscow University Evgenii Dynkin and many other academics also taught in the school.²⁹

In the meantime, in September 1962, on the initiative of the director of the Leningrad branch of the Steklov Mathematical Institute Georgii Petrashen' and mathematician Viktor Zalgaller, School #239 in Leningrad was turned into a school with advanced math and physics instruction.³⁰ At the same time, two others math and physics schools, #30 and #38, were open in the vicinity of Leningrad University. Leading academic mathematicians and physicists developed the curriculum, and often taught in these schools as well, since regular teachers were not trained to teach advanced courses. In spring 1963, the University forged an agreement with Leningrad Boarding School #7 to select 120 students for 4 specialized math classes. The arrangement was kept secret from the Leningrad City Department of Education, which did not like the University's involvement in school activities.³¹ Similar initiatives emerged at Moscow, Novosibirsk, and Kiev universities.³²

Eventually the Soviet government yielded to the lobbying of the academic scientists. In August 1963, it adopted a resolution formally establishing four boarding schools with advanced training in physics and mathematics or chemistry and biology, affiliated with four major universities in Moscow, Leningrad, Kiev, and Novosibirsk.³³ University professors and academic researchers were closely involved in shaping the curriculum and teaching at these schools. Soon similar boarding schools were established in the Soviet republics of Armenia, Georgia, Kazakhstan, and Lithuania, and in other regions of Russia.³⁴ The boarding schools served only students living outside major university centers, while the network of math schools in Moscow and Leningrad also continued to grow.

Students were selected through a network of math competitions and rigorous oral and written entrance exams. The selection took into account only math and physics knowledge and promise, completely ignoring the applicants' previous school record, emphasizing that the math schools used criteria different from the rest of the Soviet educational system.³⁵

²⁹ Nikolai Konstantinov, interview by Liubov' Borusiak, September 29, 2010 (<http://www.polit.ru/article/2010/09/29/matheducation/>). On the wide involvement of Soviet professional mathematicians in school education, see Alexey Sossinsky, "Mathematicians and Mathematics Education: A Tradition of Involvement," Chapter 5 in *Russian Mathematics Education: History and World Significance*, eds. Alexander Karp and Bruce R. Vogeli (Singapore: World Scientific, 2010), pp. 187–222.

³⁰ Lev Lur'e, in "Fiziko-matematicheskie shkoly," TV program on Channel 5, Russia, October 18, 2008 (<http://www.5-tv.ru/video/502760/>).

³¹ T. V. Burkova, *FMSH #45—Akademicheskaya gimnaziia: Ocherki istorii* (St. Petersburg, 1993) (<http://www.agym.spbu.ru/lib/BurkovaTV.doc>).

³² Two influential scholars, mathematician Andrei Kolmogorov and physicist Isaak Kikoin, played a key role in the establishment of the Boarding School of Physics and Mathematics at Moscow University; see Abramov, *Kikoin. Kolmogorov. FMSH MGU*. Mathematicians Mikhail Lavrent'ev and Aleksei Liapunov were the driving force behind the organization of the Boarding School of Physics and Mathematics in Novosibirsk; see N. A. Liapunova and Ia.I. Fet, comps., *Aleksei Andreevich Liapunov* (Novosibirsk: GEO, 2001), pp. 154–233.

³³ "Ob organizatsii spetsializirovannykh shkol-internatov fiziko-matematicheskogo i khimiko-biologicheskogo profilya," USSR Council of Ministers Resolution #905, August 23, 1963; reprinted in Abramov, *Kikoin. Kolmogorov. FMSH MGU*, pp. 159–160.

³⁴ V. Vavilov, A. Kolmogorov, and I. Tropin, "FMSH pri MGU—15 let," *Kvant*, no. 1 (1979): 55–57.

³⁵ Alexandre Borovik, "'Free Maths Schools': Some International Parallels," *The De Morgan Journal*, vol. 2,

In the last two grades of high school, math school students in effect took university-level classes and came to Moscow University well equipped for advanced courses.³⁶

While the boarding schools were controlled by university administration, city math schools had more flexibility, and some of them turned into oases of free spirit within the rather restrictive Soviet school system. Such schools upheld a distinct ethos of meritocracy and resistance to dogma and authority. Instead of feeding students pre-packaged chunks of knowledge, their teachers, often academic researchers, shared with students the spirit of academic inquiry, leading them to discover everything for themselves, taking nothing on faith, and encouraging open dispute. This education was founded on the principle that the value of knowledge is in the freedom it grants.³⁷ When asked about the level of mathematical training at math schools, one teacher replied, “We don’t teach people to be mathematicians—we teach them to be free.”³⁸

University undergraduates, who often taught advanced subjects in math schools, played a key role, radically reducing the age and power difference between teachers and students, and fostering students’ initiative and self-esteem. Math school graduates often returned to their schools to teach, establishing continuity in the transmission of both mathematical knowledge and ethical principles and helping form a closely knit community. The graduates of these schools were so different from the rest that they easily recognized each other in a university crowd. The independence of their thinking and the striving for intellectual freedom clearly set them apart from those in whom Soviet schooling inculcated conformity from an early age.

Faced with the spirit of independent thinking, the conservative university administration viewed math schools graduates as troublemakers and a “ready-made rival group” and began blocking their admission to the Faculty of Mechanics and Mathematics.³⁹ One Moscow University professor, unable to oppose administration policies, bitterly remarked, “The machine built to weed out the Jews began to be used against any able people.”⁴⁰

University professors and undergraduates who taught at math schools were usually unpaid volunteers, and this left them a lot of freedom in shaping the curriculum. One such instructor called this voluntary teaching movement “shadow pedagogy,” which, similarly to “shadow economy,” functioned outside of the sphere of official control.⁴¹ The relative autonomy of specialized school made them attractive for non-orthodox and liberal thinkers. One geneticist, who suffered persecution by the Lysenkoites and could not obtain academic employment, found refuge in the Leningrad Boarding School as a biology teacher.⁴² The prominent dissident and singer songwriter Yulii Kim worked at the Moscow Boarding School as a literature and history teacher. Another dissident, Anatolii Yakobson, one of the

no. 2 (2012): 23–35.

³⁶ Aleksandr Krauz, in *Zapiski o Vtoroi shkole* (<http://ilib.mccme.ru/2/07-krauz.htm>).

³⁷ Lev Lur’e, in “Fiziko-matematicheskie shkoly.” See also Borovik, “Free Maths Schools,” p. 28.

³⁸ Yu. S. Ilyashenko and A. B. Sossinsky, “The Independent University of Moscow,” *EMS Newsletter* (March 2010): 38.

³⁹ Konstantinov, interview.

⁴⁰ Yulii Ilyashenko, interview by Nataliya Demina, July 28, 2009 (<http://polit.ru/article/2009/07/28/ilyashenko2/>).

⁴¹ Sergei Smirnov, in *Zapiski o Vtoroi shkole* (<http://ilib.mccme.ru/2/29-smirnov.htm>).

⁴² A. N. Veselkov, quoted in Burkova, *FMSH #45*.

contributors to the underground *Chronicle of Current Events*, taught literature and history in School #2.

After Soviet dissidents publicly protested against the Soviet invasion of Czechoslovakia in August 1968, the authorities began cracking down on the dissident movement. Several specialized math schools were purged of the “undesirable” faculty. Kim and Yakobson were forced to leave, and the principals of School #2 and of the Moscow Boarding School lost their jobs; other teachers often left in protest. In Leningrad, Schools #38 and #30 were merged and moved to the outskirts of the city; School #121 was shut down.⁴³ The teachers who were fired or left in protest, however, often found employment in other schools, further spreading the ethos of the parallel social infrastructure of Soviet mathematics.

The Jewish People’s University

In 1978, Kanevskii, Senderov, and Bella Subbotovskaia, outraged by the Mekhmat discriminatory practices, organized informal open courses based on the Mekhmat curriculum for the “undesirables” rejected by Moscow University. Once or twice a week students gathered in private apartments or in empty university rooms, where university professors and other leading mathematicians gave lectures, conducted seminars, and offered exams—all without pay. As many students were already familiar with the content of basic Mekhmat courses, lecturers came up with more advanced topics.⁴⁴ This became informally known as “People’s University,” nicknamed “Jewish People’s University,” as many of the students were Jewish. The gatherings went under innocent labels, such as “courses for improving the qualifications of lecturers in evening mathematical schools,” to deflect the suspicion of the authorities. The 1978 group included just 14 students; in later years, about 100 students attended the lectures every year.⁴⁵ Ironically, some Mekhmat students also came to People’s University, as the quality of teaching and the level of students were rivaling Mekhmat.

In June 1982, the KGB finally decided to put an end to the dissident activities of Kanevskii and Senderov, who not only organized the Jewish People’s University, but also distributed anti-Soviet leaflets, possibly made on the same underground photocopying equipment they used to make copies of math lecture notes and handouts for the University. They were arrested and accused of anti-Soviet activities. Bella Subbotovskaia, the chief driving force behind the University, was pressured by the KGB to testify against them, but she refused. Within a few days, she was killed by a truck under most suspicious circumstances.⁴⁶ By the time Jewish University was eventually shut down, more than 350 students had gone through its curriculum.

⁴³ Sossinsky, “Mathematicians and Mathematics Education,” pp. 204–206; G. I. Kataev, “Ob A. N. Kolmogorove,” in *Kolmogorov v vospominaniakh*, ed. Al’bert N. Shiryaev (Moscow: Nauka, 1993), p. 466.

⁴⁴ Zelevinsky, “Remembering Bella Abramovna,” p. 194.

⁴⁵ A. Belov-Kanel’ and A. Reznikov, “Ob istorii Narodnogo Universiteta,” *Matematicheskoe prosveshchenie*, series 3, no. 9 (2005): 30–31.

⁴⁶ Dmitry B. Fuchs, “Jewish University,” in *You Failed Your Math Test*, ed. Shifman, pp. 187–189.

While the leading universities, such as Moscow University, the Moscow Institute of Physics and Technology, and the Moscow Engineering Physical Institute, were closed to the Jews, several lesser schools were designated as safe havens for the “undesirables.” These were largely engineering schools—the Moscow Institute of Transport Engineers (MIIT), the Moscow Institute of Steel and Alloys (MISiS), the Moscow Institute of Petrochemical and Gas Industry (MINKh i GP), and others.⁴⁷ As a result, these schools acquired groups of extremely strong students. The MIIT math team was so strong that during the 1976 competition it won its division and requested a transfer to the upper division to compete against the Moscow University team. The competition organizers blocked this move. The MIIT team then obtained the upper division’s problem set and started working on it, intending to show their capability. They were disqualified to prevent an explicit comparison with the Moscow University team results.⁴⁸

Alternative sites of research and publication

Since it was virtually impossible for the “undesirables” to obtain an academic position, a large pool of mathematical talent became available for employment elsewhere. Numerous applied mathematics institutes and computer centers obtained highly qualified researchers. Some institutions even created large centers of theoretical mathematics. The Institute of the Problems of Information Transmission in Moscow, for example, set up a laboratory for “complex information systems,” which in fact led fundamental mathematical research. This laboratory employed a number of outstanding mathematicians, three of whom—Grigory Margulis, Maxim Kontsevich, and Andrei Okounkov—later received the highly prestigious Fields Medal.⁴⁹

Several leading mathematicians used their influence and connections to secure employment for the talented “undesirables.” For example, Israel Gelfand, who due to his contributions to military research became part of the academic establishment, used his connections to create new elements of research infrastructure outside of control of the official leaders of the mathematics community. In particular, he set up a network of laboratories for mathematical methods in biology at Moscow University and at other institutions, and thus conjured up positions for many of his students and disciples. This phenomenon curiously mirrored the earlier efforts of Soviet geneticists to find a niche for their research outside the network of biological institutions controlled by the followers of Lysenko. The geneticists found such safe havens in physical and chemical institutions.⁵⁰

Gelfand also wielded his position as editor-in-chief of the journal *Functional Analysis and Its Applications* to publish research papers of “undesirables,” who would not have been able to publish in regular journals. To accommodate a wider range of topics under the umbrella of his journal, Gelfand eagerly treated many mathematical fields as “applications”

⁴⁷ Mark Saul, “Kerosinka: An Episode in the History of Soviet Mathematics,” *Notices of the AMS*, vol. 46, no. 10 (November 1999): 1217–1220.

⁴⁸ Berezin, “Letter to Academician R. V. Khokhlov,” p. 233.

⁴⁹ Tsfasman, “Sud’by matematiki v Rossii.”

⁵⁰ See Mark B. Adams, “Biology After Stalin,” *Survey*, vol. 23, no. 1 (Winter 1977–78): 53–80.

of functional analysis. When asked if an article would fit the subject of the journal, he usually replied, “A good article always fits the subject.”⁵¹ The need to jam a large number of research reports into the condensed space of a single journal forced him to demand unusual brevity from its authors. Thus the “Russian style” of brief mathematical notes was born: short articles of one or two pages included only the main results and omitted the proofs, causing much frustration for the readers.

Gelfand’s significant influence and his ability to leverage this influence to sustain and expand his network of collaborations strengthened the parallel social world of mathematics, but at the same time closely tied it to the mainstream infrastructure. Too often, Gelfand’s disciples became dependent on their mentor, both administratively (he gave them jobs) and intellectually (he strongly shaped their way of thinking). Some of his students were able to overcome this dependency and became outstanding mathematicians in their own right. Others remained reliant on Gelfand’s leadership. In this sense, although Gelfand did create a parallel social environment, his relations with his students in some ways replicated the patronage pattern, typical of the Soviet academic hierarchy. At the same time, Gelfand, who always worked with co-authors, was dependent on his disciples. He drew on their interests and strengths to expand the scope of his research program. The same qualities that allowed Gelfand to become the creator of a parallel world also caused this world to resemble, ironically, its opposite, the official hierarchical world of Soviet mathematics. The most important difference, however, was that the parallel world offered little or no material reward, compared to the official world. Only those truly dedicated to mathematics were motivated to enter this parallel universe.

Open seminars

While the regular curriculum at Mekhmat remained fixed, leading mathematicians affiliated with Moscow University—Vladimir Arnold, Israel Gelfand, Aleksandr Kirillov, Yurii Manin, Sergei Novikov, Ernest Vinberg, and others—offered specialized seminars for undergraduate students. These seminars covered a wide range of topics beyond the rigid Mekhmat curriculum. The system of open seminars, which gave instruction in the most recent, booming fields of mathematics, became a key component of the parallel social infrastructure. Since these seminars were offered outside the regular curriculum, attending them did not bring students any credit. In fact, many participants were not university students at all but came from outside the university, figuratively or literally climbing the fence.

Some seminars included, besides undergraduates, also mid-career and senior researchers; other seminars functioned in two modes—“minor,” for undergraduates, and “major,” for more advanced researchers. For the “undesirables,” barred from university education or professional employment by discriminatory policies, such seminars provided vital access to the latest trends in the mathematical community and an opportunity to meet other mathematicians and find mentors and collaborators. By ignoring the division between uni-

⁵¹ Aleksandr Kirillov, in *My—matematiki s Leninskikh gor*, ed. A. Yartseva (Belova) (Moscow: Fortuna, 2003), p. 294.

versity and non-university mathematicians and creating a social space lying outside the official institutional framework of Soviet mathematics, the seminars fostered conditions for expanding informal social circles and networks.

The most famous and influential of those was the seminar led by Israel Gelfand at Moscow University for more than 45 years, from 1943 to 1990.⁵² Initially established as a seminar on functional analysis, it quickly expanded to include a wide range of mathematical fields. Some participants described its coverage as “all of mathematics.”⁵³ Foreign visitors and Soviet mathematicians returning from foreign trips were immediately asked to present at the seminar on the latest research trends. A regular participant recalled, “It was Gelfand’s intention to understand mathematics as a whole; no problem in mathematics was irrelevant to his seminar.”⁵⁴ The breadth of the seminar coverage and its phenomenal role in the mathematical community owed much to the figure of its leader, the wide span of his own research interests, his profound interest in fundamental issues, penchant for the search for connections among different fields, outstanding ability to pose new research questions, and openness to new collaborations.⁵⁵

The seminar attracted mathematicians from all over Moscow and often from other cities and became a regular social gathering, a mathematical club of sorts, where most recent results and new ideas were informally discussed before or after the main presentation. “People gathered at the blackboard and wrote formulas or walked back and forth in the hall and talked,” recalls one of the participants.⁵⁶ “A typical Russian formation—two people are discussing mathematics and slowly walk down the corridor, turn around, and slowly walk back,” recalled an American visitor.⁵⁷

Run by Gelfand in a highly idiosyncratic manner, this seminar constituted an unusual semi-public, semi-private space. Gelfand repeatedly broke conventional rules of academic discourse by interrupting speakers, calling participants to the blackboard, and dispatching mocking remarks. He often spiced up his mathematical remarks with Jewish anecdotes and risky jokes, further undermining the boundary between academic and non-academic language. In this sense, his seminar was a semi-private space ruled by playfulness and intellectual freedom, in which the rules of official Soviet academic discourse did not apply.

Subjecting many speakers, including senior ones, to relentless pressure and sometimes even ridicule, Gelfand effectively broke social hierarchies and made his seminar a

⁵² On the early years of the seminar, see M. I. Vishik and G. E. Shilov, “O seminarie I. M. Ge’fanda po funktsional’nomu analizu i matematicheskoi fizike v MGU,” *Uspekhi matematicheskikh nauk*, vol. XIII, vyp. 2 (80) (March–April 1958): 253–263.

⁵³ Vladimir Tikhomirov, in *Mekhmatyane vspominayut*, ed. V. B. Demidovich (Moscow: MGU, 2008), p. 10.

⁵⁴ Ilya Piatetski-Shapiro, “Étude on Life and Automorphic Forms in the Soviet Union,” in *Golden Years of Moscow Mathematics*, eds. Zdravkovska and Duren, p. 209.

⁵⁵ Gelfand published 560 research papers and monographs with numerous co-authors in many fields of mathematics. With 748 citations, he was the second most cited mathematician in the world in 1978–79; see “The 200 ‘Pure’ Mathematicians Most Cited in 1978 and 1979,” *Essays of an Information Scientist*, vol. 5 (1981–82): 666–675. For a collection of memoirs about Gelfand, see Retakh, ed., “Israel Moiseevich Gelfand, Part I,” 24–49.

⁵⁶ Alexey Sossinsky, interview by Nataliya Demina, October 20, 2009 (http://www.polit.ru:8021/article/2009/10/20/absossinsky_about_imgelfand/). Sossinsky calls the seminar “a Mekhmat club”; many seminar participants, however, came from outside the university.

⁵⁷ Robert D. MacPherson, interview by Robert L. Bryant, May 12, 2011 (https://simonsfoundation.org/science_lives_video/robert-d-macpherson/), part 17.

place where only intellectual expertise counted. According to one participant, Gelfand “could destroy a talk by an eminent expert at the very beginning by interrupting it, telling the audience that the speaker’s approach was basically flawed, very convincingly explaining why, concluding that the seminar could not waste its time listening to the rest of the talk, and then calling on the next speaker on the agenda to begin the report to follow.”⁵⁸ The seminar goers learned to accept no claim merely on the authority of the speaker, cultivating well-organized skepticism on a scale that might be excessive even for Robert Merton’s idealized norms of the scientific community.⁵⁹ This radical move defied the highly hierarchical Soviet system of organization of research, in which leading mathematicians possessed enormous administrative power and could rarely be challenged by junior researchers, who were viewed more as subordinates than as colleagues. At the Gelfand seminar, however, mathematicians of different social status discussed problems on an equal footing. The seminar attracted young talent because it offered participation in a closely knit community, which had its own internal mechanisms for building a scholarly reputation, independent of one’s status in the Soviet institutional hierarchy.

The Gelfand seminar never ended on time, running until 11 pm or even later. The main factor usually limiting the length of the seminar was the appearance of a cleaning lady wishing to do her job in the seminar room.⁶⁰ One of Gelfand’s disciples explicitly contrasted this feature of the Gelfand seminar with the rigid rules of mathematical seminars in the West, which always end on time, even if this interrupts the proceedings in the middle of discussion.⁶¹ In Gelfand’s world, nothing could take precedence over mathematics—neither administrative rules, nor family obligations. The math talk flowed seamlessly from the seminar room into the informal conversations that followed, often until 1 a.m., the subway closing time. This blurred the boundary between the public space of the seminar and the private world of informal communication, with its use of colloquial language and ad hominem remarks. The seminar as a social phenomenon effectively transformed mathematics as an academic activity into a personal, even spiritual experience.

Around the Gelfand seminar emerged a community dedicated to mathematics far beyond any formal obligation of study or work. For his students and disciples, mathematics was a way of life—not very comfortable, somewhat unsafe, but exciting and highly rewarding—not in the common sense of formal distinctions and institutional careers, but in the sense of hard-won recognition by peers and maybe even by Gelfand himself.

Besides Gelfand’s seminar, several other large seminars in Moscow and Leningrad played an important role in the parallel social infrastructure. Each was centered around the figure of its leader, an outstanding mathematician, followed by a cohort of disciples. Some of the features of these seminars were very similar to Gelfand’s: the focus on cutting-edge research, the openness to students and researchers from outside the University, and the

⁵⁸ Sossinsky, “Mathematicians and Mathematics Education,” p. 198.

⁵⁹ In 1942 Robert Merton listed “organized skepticism” among the “four sets of institutional imperatives [comprising] the ethos of modern science”; “The Normative Structure of Science” [1942], in *The Sociology of Science: Theoretical and Empirical Investigations* (Chicago, Ill.: University of Chicago Press, 1979), p. 270.

⁶⁰ Simon Gindikin, “Foreword,” in *I. M. Gelfand Seminar* (Advances in Soviet Mathematics, vol. 16, part 1) (Providence, RI: AMS, 1993), p. xiii.

⁶¹ Ilya Zakharevich, interview by the author, Cambridge, Mass., May 19, 2012.

formation of a research school around the social hub of the seminar. The personalities of their leaders, however, made a decisive impact on the character and role of their seminars. Most seminars were limited to the range of research interests of their leaders, none aspiring to the wide coverage exemplified by Gelfand's seminar.

Other seminars were largely the gatherings of their leaders' research schools, while the Gelfand seminar had a much wider audience. Although Gelfand might have viewed his seminar partly as a recruitment tool for his school, the social infrastructure that he created acquired certain purpose and significance of its own. His seminar transcended the boundaries of his school. In order to maintain his seminar's status as the leading gathering of Moscow mathematicians, Gelfand had to appeal to a wider mathematical audience beyond the circle of his disciples.

Fruits of the parallel social infrastructure

Major Soviet universities and academic institutions of Soviet mathematics forced so many "undesirables" out of the system that a critical mass of mathematical talent was formed outside the confines of the mathematical establishment. Using their positions within the establishment, some of the leading mathematicians—Gelfand, Arnold, Manin, Novikov, Vladimir Rokhlin, and a few others—created a parallel social infrastructure, an informal "invisible college," in which both their "official" students and unofficial disciples could study, exchange ideas, and collaborate in research. The size of this "invisible college," unrestricted by funding or administrative limitations, grew to create arguably the largest mathematical community in the world, concentrated in Moscow and Leningrad. The state-imposed constraints on geographic mobility cemented this community, creating a core of seminar participants who would come to the same seminar for decades, sustaining its spirit and providing continuity.

The success and international reputation of Soviet mathematics were largely due to this parallel social infrastructure. It is instructive to examine the professional biographies of three Soviet-era mathematicians who became Fields Medal laureates. The Fields Medal, often regarded as the analog of a Nobel Prize for mathematicians, is awarded every four years to up to four most outstanding mathematicians under 40 years old at International Mathematics Congresses. These awards bestow a great honor on individual mathematicians, as well as indicate the areas in which the most important mathematical breakthroughs have occurred. All three Soviet Fields Medal laureates who were awarded the medal during the Soviet era were active participants in the parallel social infrastructure.

Sergei Novikov (b. 1938) was awarded the 1970 Fields Medal. The son of two prominent mathematicians, he early on achieved outstanding results. While still an undergraduate, he organized his own research seminar on algebraic topology for younger students, because regular courses in this new field were unavailable. He also attended the Gelfand seminar. Initially Novikov was showered by the Soviet authorities with awards, promotions, and a corresponding membership in the Academy of Sciences. Repelled by the practices of favoritism and anti-Semitism, however, he turned down the offer to become deputy director of the Institute of Mathematics and grew increasingly alienated from the

mathematics establishment. In March 1968, along with other prominent mathematicians, he signed a letter protesting the forced institutionalization in a psychiatric hospital of the human rights activist and mathematician Aleksandr Esenin-Vol'pin.⁶² Along with other signers, he suffered persecution, which affected his career and curtailed his plans for visits abroad. In particular, the Soviet authorities barred him from attending the International Congress of Mathematicians in Nice, where he was to receive his medal.⁶³ Novikov was awarded the medal only a year later, at an international conference in Moscow, after significant pressure from the leaders of the International Mathematical Union.⁶⁴

Grigory Margulis (b. 1946) was awarded the 1978 Fields Medal. The Soviet authorities similarly did not permit him to attend the Congress in Helsinki, where the medal was to be awarded. While an undergraduate student, he participated in several open seminars, including the Gelfand seminar.⁶⁵ After graduation, because of his Jewish background, Margulis could not obtain a position at Moscow University or at the Mathematical Institute of the Soviet Academy of Sciences. With Gelfand's help, he was able to secure employment at the Institute of Problems of Information Transmission, a research institution for applied mathematics.⁶⁶ When the Fields Medal committee decided to award the 1978 medal to Margulis, Lev Pontryagin, the Soviet representative in the Executive Committee of the International Mathematical Union, strongly objected, labeling Margulis's work as second-rate. Pontryagin retreated only after a threat to expel the Soviets from the Mathematical Union. Nevertheless, Margulis was not allowed to travel to Helsinki to receive the medal, apparently due to the machinations of the Soviet mathematics establishment.⁶⁷

Vladimir Drinfeld (b. 1954) was awarded the 1990 Fields Medal. The winner of the 1969 International Mathematics Olympiad for high school students, he enrolled in Moscow University without passing entrance examinations and thereby circumvented possible discrimination on the basis of his Jewish background. A student of Yuri Manin, he matured as a mathematician in Manin's seminar, while also attending the Gelfand seminar. After graduation, because of his Jewish background and the lack of Moscow residence permit, he could not find employment in Moscow.⁶⁸ Drinfeld had to leave for the city of Ufa, where he taught at a peripheral institution, Bashkir State University. In 1978 he was an invited

⁶² On Esenin-Vol'pin, see Benjamin Nathans, "The Dictatorship of Reason: Aleksandr Vol'pin and the Idea of Rights under 'Developed Socialism,'" *Slavic Review*, vol. 66, no. 4 (Winter 2007): 630–663. For the text of the letter, see Aleksandr Esenin-Vol'pin, *Filosofiya. Logika. Poeziya. Zashchita prav cheloveka* (Moscow: RGGU, 1999), pp. 328–330.

⁶³ "Sergei Novikov," in *Fields Medallists' Lectures*, eds. Sir Michael Atiyah and Daniel Iagolnitzer (Singapore: World Scientific, 2003), p. 207.

⁶⁴ Olli Lehto, *Mathematics Without Borders: A History of the International Mathematical Union* (New York: Springer, 1998), pp. 175, 352.

⁶⁵ Grigory Margulis, interview by Evgenii Dynkin, Moscow, September 12, 1989; Cornell University Library, the Eugene B. Dynkin Collection of Mathematics Interviews (<http://dynkincollection.library.cornell.edu/sites/default/files/Margulis%20Eng.-Final.pdf>).

⁶⁶ I. A. Ovseevich, "Vospominaniya k 40-letiiu deyatel'nosti IPPi RAN," (http://www.ippi.ru/ru/about/ovseevich_40).

⁶⁷ Lehto, *Mathematics Without Borders*, pp. 205–206.

⁶⁸ According to Soviet laws, without a residence permit one could not be employed. At the same time, one could not obtain a residence permit without having a local job. This effectively reduced geographic mobility to a minimum. In particular, this made it extremely difficult for non-Muscovites to secure a job in Moscow.

speaker at the International Congress of Mathematicians in Helsinki, a rare honor for a 24-year old mathematician, but the Soviet authorities did not let him go. Pontryagin “criticized the choice of invited speakers,” and of the 28 invited Soviet mathematicians, only 14 were allowed to go.⁶⁹ In 1981 Drinfeld moved to the city of Kharkov in Ukraine and began working at a physics research institute. In 1986 he was again invited to give a lecture at the International Congress in Berkeley, and was again denied this opportunity.⁷⁰ In 1990, with the political changes that occurred during Gorbachev’s perestroika, Drinfeld was finally allowed to travel to the International Congress in Kyoto, where he received his medal. In 1998 he moved to the United States and accepted Distinguished Service Professorship at the University of Chicago. In Chicago, he leads an open seminar, which “following, perhaps, the tradition of the famous Gelfand Seminar in Moscow . . . runs regularly now on Mondays from 4:30 pm until both the speaker and the participants are totally exhausted.”⁷¹ The ethos of the parallel social infrastructure, cultivated at the Gelfand seminar, was carried across the ocean.

Even in the post-Soviet times the cultural split between the two parallel worlds persists. Instead of reforming Mekhmat, the mathematical community transformed the Soviet-era parallel social infrastructure into new institutions, which preserve the alternative spirit and traditions of the parallel world—the Independent University of Moscow (1991), the Moscow Center of Continuous Mathematical Education (1997), and the Faculty of Mathematics of the Higher School of Economics (2008).⁷²

Conclusion

Soviet mathematics was not shielded from political or administrative pressures; it was subjected to them along with other disciplines. Its abstract subject matter did not save it from discrimination or from various constraints, often imposed by conservative institutional hierarchies. The mathematicians succeeded, however, in creating a parallel social infrastructure, which opened venues for collaboration, disseminated latest results, and welcomed innovative ideas.

Instead of public spaces, mathematics was often practiced in private or semi-private spaces—in home kitchens, at summer dachas, during nature walks, at individual meetings with volunteer mentors, or at seminars that were not part of the formal educational system,

⁶⁹ Lehto, *Mathematics Without Borders*, pp. 205–206.

⁷⁰ The prominent French mathematician Pierre Cartier later recalled, “I had the very fortunate opportunity to be asked to deliver the lecture on behalf of Vladimir Drinfeld at the International Congress of Mathematicians at Berkeley in 1986 (Drinfeld was prevented from coming for political reasons). It was a great challenge and a great honor for me; his paper is one of the most important papers in the proceedings. Overnight that changed my mathematical life. I said, ‘This is what I have to do now.’”; Marjorie Senechal, “The Continuing Silence of Bourbaki—An Interview with Pierre Cartier, June 18, 1997,” *Mathematical Intelligencer*, vol. 20, no. 1 (1998): 28.

⁷¹ Victor Ginzburg, “Preface,” *Transformation Groups*, vol. 10, nos. 3–4 (Special issue on the occasion of Vladimir Drinfeld’s 50th birthday) (2005): 277.

⁷² See Ilyashenko and Sossinsky, “The Independent University of Moscow”; Sossinsky, “Mathematicians and Mathematics Education,” pp. 215–218; Sergei Lando, interview by Nataliya Demina, *Troitskii variant*, no. 17N (851) (25 November 2008): 4 (<http://www.scientific.ru/trv/17N.pdf>).

such as the Gelfand seminar. Although the seminar was public, Gelfand's idiosyncratic style made it essentially a semi-private matter, an informal gathering that broke social hierarchies and rigid rules of academic discourse, at the same time opening up space of intellectual autonomy.

If the American feminists' motto in the 1970s was "the personal is political," Soviet mathematicians made the mathematical personal. Many of them were not paid to do mathematical research; they often had to work other jobs. By devoting their free time to mathematics, they felt being part of a like-minded community and acquired a sense of self-worth. As Robert MacPherson, who often visited the Soviet Union, has put it, "It was a mathematical paradise. Good mathematicians were doing this as a hobby, not because they were paid to do it."⁷³

Sociologists have long stressed the complex interplay between formal bureaucratic structures (research institutes, academies, editorial boards, etc.) and informal associations (science schools, research groups, social circles, and professional cliques) in science.⁷⁴ In Soviet science, with its rigid hierarchies, large, inflexible institutions, and the abundance of complex regulations, informal mechanisms became a major tool for overcoming the bottlenecks and inertia of the existing administrative system.⁷⁵ Leaders of science schools lobbied for government support and secured positions and promotions for their disciples. Research groups were formed to manage interdisciplinary projects that did not fit into the central-planning, block-funding, conservative system of Soviet research management. Joining social circles helped scientists meet new colleagues, build trust, and establish collaborations. Professional cliques helped their members defend their research areas from invasion by rival groups. Both senior scientists at the top of the administrative hierarchy and junior researchers in the margins of the academic community actively used various informal mechanisms to advance their agendas. Senior scientists strengthened their power through networks of influence, while junior researchers advanced by establishing connections, gaining visibility, and building their reputations.⁷⁶

The formal structures and informal mechanisms of Soviet science were not entirely separate; their very existence presupposed each other. One often needed to use informal strategies to activate formal bureaucratic actions, and vice versa. For example, a formal defense of a doctoral dissertation often required considerable informal efforts in securing the support of powerful patrons and allies. The interplay of formal and informal mechanisms in Soviet science strongly resembled the interdependence of the "first" and "second"

⁷³ MacPherson, interview, part 17.

⁷⁴ See Charles Kadushin, "Networks and Circles in the Production of Culture," in *The Production of Culture*, ed. R. Peterson (Beverly Hills, Calif.: Sage, 1976), pp. 107–122; S. R. Mikulinskii, ed., *Shkoly v nauke* (Moscow: Nauka, 1977); M. J. Mulkay, "Sociology of the Scientific Research Community," in *Science, Technology, and Society*, eds. I. Spiegel-Rosing and D. de Solla Price (London: Sage, 1977), pp. 93–148.

⁷⁵ See Linda Lubrano, "The Hidden Structure of Soviet Science," *Science, Technology, and Human Values*, vol. 1, no. 2 (Spring 1993): 147–175.

⁷⁶ The Landau school in physics and the Pavlov school in physiology are two textbook examples. See Alexei B. Kojevnikov, *Stalin's Great Science: The Times and Adventures of Soviet Physicists* (London: Imperial College Press, 2004), chap. 10; Nikolai Kremensov, *Stalinist Science* (Princeton, N. J.: Princeton University Press, 1997), chap. 9.

economies in the Soviet Union.⁷⁷

Similarly, the parallel social infrastructure of Soviet mathematics was not completely detached from established institutions. Research seminars met in the main building of Moscow University; the results were published in official journals; and mathematicians were employed in government-controlled institutions, even though often in non-academic ones. Their working conditions allowed them sufficient free time to come to seminars, conduct research, and teach at math schools, apart from their regular job duties. The parallel social infrastructure was therefore dependent on the official infrastructure and partly mirrored some of the features of the system that it was created to oppose.

In one sense, however, the line between the official establishment and the parallel social structures in Soviet mathematics was clear: the latter supported an alternative value system, a cultural environment, in which mathematicians not only did good mathematics, but also cultivated a group identity distinct from the officially declared Soviet values. Perhaps this was why they were able to do good mathematics.

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⁷⁷ See G. Grossman, "The 'Second Economy' of the USSR," *Problems of Communism*, vol. 26, no. 2 (September-October 1977): 5–40; G. Grossman, "The Second Economy: Boon or Bane for the Reform of the First Economy?" in *Economic Reforms in the Socialist World*, edited by S. Gomulka, Y. C. Ha, and C. O. Kim (New York: Macmillan, 1989), pp. 79–95; and Alena Ledeneva, *Russia's Economy of Favours: Blat, Networking and Informal Exchange* (Cambridge, UK: Cambridge University Press, 1998).