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Algorithm's Cradle:
Commemorating al-Khwarizmi in the Soviet History of Mathematics and Cold War Computer Science

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ABSTRACT

This chapter investigates the origin narratives and commemoration practices that came hand in hand with the growing cultural authority of the algorithm after World War II, culminating in celebrations in honor of the 1,200th anniversary of the medieval scholar Abu ʿAdallah Muhammad Ibn Musa al-Khwarizmi. I first show how al-Khwarizmi's legacy was claimed by Soviet historians of mathematics aiming to construct a history inspired by dialectical materialism, a goal that eventually led to arguments about the distinct, algorithmic character of mathematics in the East. Next, I study how these ideas were appropriated by the international community of computer scientists in search of the origins for their discipline. The late-Soviet coupling of commemoration rituals with programming literacy campaigns evolved into an enduring cultural reference shared across post-Soviet spaces. Such alternative symbolic lives of the algorithm suggest a need to suspend assumptions of universality in historicizing the global modalities of algorithmic culture.

The history of the algorithm has been claimed. It has been claimed not as part of the contemporary enchantment with the promises of big data and artificial intelligence to optimize global capitalism but rather as part of a much earlier moment, in the late 1970s and the early 1980s. The timing of this moment, often described as a "personal computer revolution" in the West, would seem not that surprising if it were associated with Silicon Valley. But even more unexpectedly, the main advocates for celebrating the algorithm's history in connection to the legacy of the medieval scholar Abu ʿAdallah Muhammad Ibn Musa al-Khwarizmi were located in the Soviet Union, the country that would disappear less than a decade later. That this history has been claimed not recently but much earlier than expected and in an unexpected place is a puzzle the solution to which lies in historicizing the algorithm from a non-Western perspective, deuniversalizing the process of historicization itself. This chapter offers both a clear-cut case illustrating the collapse of the opposition between human judgment and mechanistic logic and

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a recursive (self-)reflection on historical knowledge as it shifts in time and place, and between communities. To examine the process of claiming the algorithm's history, I conjugate two established genres in the history of science; namely, the studies of commemorative practices and the history of science studies.[1]

For Soviet historiography, this undertaking is not only a methodological experiment but an analytical move that requires uncoupling the algorithm as culture from political and technological failures. The Soviet setting for the algorithm's origin story appears particularly perplexing, as the difficulties for Soviet computing industries in mass producing hardware and the absence of a Soviet national computer network are well known and often are too readily accepted as facts defining the Soviet failure narrative at the price of ignoring rich, alternative cultures of computation.[2] In particular, continuities between the turn-of-the-twentieth-century discussions of *poznaniye* (an epistemic orientation toward the process of knowledge acquisition in the Russian empire) and the postwar rise of the Soviet school of mathematical logic underline both the humanistic vision of the algorithm as a mathematical object bridging the inner and outer worlds and the characteristic understanding of programming not as a narrow skill but as a matter of consciousness.[3] In other words, to dismiss the Soviet claims to the history of the algorithm as a fluke of sorts is to misinterpret historical forces that propelled the rise of the algorithm in both the capitalist and the socialist versions of modernity.[4]

The algorithm's origin story and its commemoration were a byproduct of a peculiar Soviet version of governance and memory construction as captured by the famous formula "nationalist in form, socialist in content." The formula underscored that minority languages, ways of life, and dress were all matters of form that could be inscribed with socialist meaning. Early Soviet nation building involved several prominent elements, such as assigning a territory to each official national minority, developing a unified and standardized national language regardless of whether one had previously existed, and defining cultural canons.[5] The commemoration in the 1980s of the mathematical past of the remote Central Asian region—comprising territories that entered the realm of Russian imperial influence as late as the second half of the nineteenth century—was but an

[1] Classical references on commemoration include two special issues of journals: Pnina G. Abir-Am and Clark A. Elliott, eds., *Commemorative Practices in Science: Historical Perspectives on the Politics of Collective Memory*, vol. 14 of *Osiris* (1999); and Jon Agar, William J. Ashworth, and Jeff Hughes, eds., "On Time: History, Science and Commemoration," special issue, *British Journal for the History of Science* 33, no. 4 (2000). For a recent work focusing on historians' engagement with scientific methods and using Russia as "a heuristic to deuniversalize history's own analytical lenses," see Elena Aronova, *Scientific History: Experiments in History and Politics from the Bolshevik Revolution to the End of the Cold War* (Chicago: Univ. of Chicago Press, 2021), 7.

[2] See Manuel Castells, *End of Millennium* (Malden, MA: Blackwell, 1998). A more recent, revisionist account of Soviet computer networking still follows a declinist story arc: Benjamin Peters, *How Not to Network a Nation: The Uneasy History of the Soviet Internet* (Cambridge: MIT Press, 2016).

[3] Ksenia Tatarchenko, Anya Yermakova, and Liesbeth De Mol, "Russian Logics and the Culture of Impossible: Part I—Recovering Intelligentsia Logics," *IEEE Annals of the History of Computing* 43, no. 4 (2021): 43–56, and "Russian Logics and the Culture of Impossible: Part II—Reinterpreting Algorithmic Rationality," in *IEEE Annals of the History of Computing* 43, no. 4 (2021): 57–69.

[4] On Soviet modernity, see Michael David-Fox, *Crossing Borders: Modernity, Ideology, and Culture in Russia and the Soviet Union* (Pittsburgh, PA: Univ. of Pittsburgh Press, 2015).

[5] See Ronald Grigor Suny, *The Revenge of the Past: Nationalism, Revolution, and the Collapse of the Soviet Union* (Stanford, CA: Stanford Univ. Press, 1993), and Yuri Slezkine, "The USSR as a Communal Apartment, or How a Socialist State Promoted Ethnic Particularism," *Slavic Review* 53, no. 2 (1994): 414–52.

instantiation of this ongoing work in the invention of an identity for the republic: al-Khwarizmi became a Soviet sobriquet for the Uzbek national genius.[6]

When, on September 6, 1983, the Soviet Academy of Sciences hosted a ceremony in honor of the 1,200th anniversary of al-Khwarizmi (of whose origins remarkably little is definitely known), the main guest of honor was Amadou-Mahtar M'Bow, the director-general of the United Nations Educational, Scientific and Cultural Organization (UNESCO).[7] That is, not only did UNESCO recognize Soviet historical claims turning al-Khwarizmi into a national hero but its director traveled to Moscow to deliver a speech on the occasion. Recognizing that al-Khwarizmi's main work was done in the Abbasid imperial capital, where the scholar belonged to Baghdad's famous center of learning, the Bayt al-Hikmah, or the House of Wisdom, M'Bow highlighted the fact that the man's own name became a standard term of the international scientific vocabulary: the term *algorithm* comes from the Latin transcription of "al-Khwarizmi." Crucially, M'Bow's discursive frame justified the anniversary character of the Moscow commemoration in connection to the medieval scholar's origin, not to the place of work: as his name indicates, al-Khwarizmi was somehow connected to the Khwarezm region, famous for its learned tradition. In the speech, however, this connection became a birthplace, located at the time on the territory of the Soviet Uzbek Republic. This birthplace represented the value of multiculturalism and the worth of historical commemoration as a site entangling the intellectual and the moral: "What history can teach us here is primarily a great lesson in humility," concluded the UNESCO leader.[8]

While M'Bow's politics of postcolonial solidarity amid the tensions provoked by the Soviet-Afghan war formed an outer layer in a set of interests that crystallized on the occasion of the 1983 celebration, they are not the focus of the present chapter. Rather, I investigate how these interests and the historical narratives about the multiculturalism of al-Khwarizmi's mathematics, his supposed birth in Uzbek Khwarezm, and his alleged relevance to digital technology became ready and available for diffusion, instrumentalization, and reinforcement.

The chapter surveys the multifold process that shaped the commemoration of al-Khwarizmi as a story encompassing both the production and the appropriation of historical knowledge, a form of dialogue between the Soviet school of the history of mathematics and the new international discipline of computer science. The 1979 conference "Algorithms in Modern Mathematics and Computer Science," held in the Uzbek city of Urgench and coorganized by the Soviet and American computer scientists Andrei Ershov and Donald Knuth, is the key event investigated here as a case that is revelatory of the circulation of ideas and multiple roles of the history of the algorithm.[9] Insofar as it

[6] The Uzbek claims on al-Khwarizmi's legacy as that of a fellow countryman (from the Russian *zemlyak*) dated from the times of World War II: T. I. Rainov, *Velikie uchenye Uzbekistana (IX–XI vv.)* (Tashkent: Isdatel-stvo UzFan, 1943).

[7] For more on M'Bow's long career, see Jeanne Lopis-Sylla and Charles Becker, eds., *Amadou Mahtar MBow, Le sourcier du futur: Un combat pour l'Afrique, un destin pour l'humanité* (Paris: L'Harmattan, 2016).

[8] Amadou-Mahtar M'Bow, "Address by Amadou-Mahtar M'Bow, Director-General of UNESCO, on the occasion of the celebration of the 1,200th anniversary of the birth of the mathematician Abu 'Abdallah Muhammad Ibn Musa Al Khwarizmi; Moscow, 6 September 1983," document DG/83/28, http://unesdoc.unesco.org/images/0005/000564/056440EB.pdf.

[9] Andrei P. Ershov and Donald E. Knuth, eds., *Algorithms in Modern Mathematics and Computer Science: Proceedings, Urgench, Uzbek SSR, September 16–22, 1979* (New York: Springer-Verlag, 1981).

constituted a pilgrimage to the birthplace of the algorithm, the conference was not an isolated event. On the one hand, the gathering was a result of the adoption by a new discipline of a particular version of the narratives about al-Khwarizmi as developed by Soviet historians of mathematics. I start this chapter by investigating the intellectual agenda of the Soviet school of the history of mathematics that led to the emphasis on the algorithm's centrality to al-Khwarizmi's legacy, accentuating its global interconnectedness and contemporaneous relevance. On the other hand, by staging the origin of computer science on the ground in Uzbekistan, the conference also highlighted how these scholarly discourses were lived as personal experiences enmeshed in the materiality of socialist myth making.

By zooming in on the emergence and circulation of the algorithm's origin history, the chapter contributes to this volume's agenda to deconstruct the future-oriented dimension of many popular and expert accounts of digital cultures by acknowledging algorithms' cultural authority, "that culture has in fact been made."[10] I show that commemorative practices actualizing al-Khwarizmi's status as the father figure associated with the algorithm were not propaganda tools designed at the top and implemented at the bottom. Rather, I see the processes leading to the 1983 anniversary celebration as a set of intersections: between Marxist philosophy and professional historical research, between the authority of historical universalism and the disciplinary identity of computer science, and, finally, between the textuality of historical production and the physicality of remembrance rituals.

Each of these intersections also speaks to different themes and methodologies developed in the volume. Akin to Matthew Jones's chapter showing the limits of the association between expert statisticians and lay users of data visualization, who share some practices and disagree on their virtues and vices, my study situates the history of the algorithm as an ongoing interlocution between different epistemic communities and abandons direct narrative.[11] I follow ideas in a circulation that is never complete, a reception that is only partial, commensurate with liberties taken. My attention to the performative character of commemoration, through which I connect historical and mathematical concepts to professional aspirations and material culture, echoes Michael Barany's embrace of materiality in "remediation" and extends his search for alternative—that is, nonbinary—imaginations of the concept of the algorithm beyond the genealogy of Western mathematics to the spaces of interdisciplinary and transnational encounters.[12] Embracing the paradoxes of the Soviet commemorative project as tied to the algorithm's particular origin point, located on the periphery of the Soviet empire in the republic of Uzbekistan, I see an opportunity to answer the editors' call for the end-to-end historiography of algorithms by incorporating Russian-language sources, encompassing Eastern geographies, and establishing a conversation between history of science and area studies.[13]

[10] James Evans and Adrian Johns, "Introduction: How and Why to Historicize Algorithmic Cultures," this volume.

[11] Matthew L. Jones, "Users Gone Astray: Spreadsheet Charts, Junky Graphics, and Statistical Knowledge," this volume.

[12] Michael J. Barany, "On Remediation: Media, Repair, and the Discipline of Fantasy in the Theory and Practice of Algorithmic Modernity," this volume.

[13] Evans and Johns, "Introduction."

The Soviet claims on al-Khwarizmi's legacy were tied to the broader framework of mathematical knowledge more generally, and the philosophical arguments about its chronological and geographical development more specifically. According to the introduction to the 1964 Russian-language translation of al-Khwarizmi's mathematical treatises on Indian numerals and on algebraic solutions to linear and quadratic equations, his works "played an exceptional role in the history of mathematics." The Soviet historians who oversaw the edition found a contextual explanation for al-Khwarizmi's mathematical creativity: in their eyes, he was drawing on the "distinctive achievements" (samobytnye dostizheniia) of pre-Islamic Central Asia, as well as neighboring India and Hellenized Asia Minor.[14] The Soviet historiography of mathematics and the exceptional status it ascribed to the Arabic-language mathematical tradition as the cultural mediator between the Indian, Greek, and medieval Latin worlds was no closeted intellectual development but part and parcel of the development of mathematical practice as grounded in Marxist historical laws.

The rise of Arabic-language mathematics as an object of study in the Soviet historiography of mathematics belongs to the account of the formation of this field. The studies on al-Khwarizmi conducted in the aftermath of World War II reflected national patterns that structured the research opportunities and intellectual priorities of the Soviet historians of mathematics. I argue that the international scale of the 1983 celebration of al-Khwarizmi was predicated on framing his achievements not only as mathematical but also as representing a certain kind of algorithmic mathematics, of particular relevance to computational practices and to information technology. Moreover, the computer scientists of the 1970s would find the work of the Soviet historians of mathematics relevant and accessible because practicing scientists had been the privileged audience of the Soviet history of mathematics from the beginning.

When we trace the reception of the Soviet history of Arabic mathematics among the circle of practitioners who identified with the new discipline of computer science, several key aspects of the relationship connecting the history of mathematics to mathematics and philosophy appear to require a revision. Irina Liuter, one of the most productive descendants of the Soviet school, has observed that before the mid-twentieth century, Russian and Soviet Orientalist studies focused not on the mathematical but on the geographical, historical, and philological works of the medieval Arab-Islamic authors.[15] I build on this observation to reflect on the role of Marxist philosophy in this shift. After analyzing the goals of the history of mathematics as expressed by the specialists who pioneered studies on Arabic mathematics, I turn to the structural patronage that enabled the growth of the field in order to connect the specific features of historical writings to their privileged audience of practitioners.

The current synthetic overview of the Soviet history of mathematics does include the role of ideology, but in a negative light and as an outside force. For instance, the renowned historian Sergei Demidov explains the highly technical work of the members of the Moscow school in the history of mathematics and the proximity between historians

[14] Muhammad al-Khwarizmi, *Matematicheskie traktaty*, trans. Iu. Kh. Kopelevich and B. A. Rozenfel′d (Tashkent: Fan, 1964), 5.

[15] I. O. Liuter, "Stanovlenie sovetskoi shkoly istorii arabskoi matematicheskoi nauki: 1940–1960e," *Voprosy istorii estestvoznaniia i tekhniki* 39 (2018): 421–44.

and the mathematical community as protective mechanisms against ideological intervention. The arcane nature of the texts is interpreted as a barrier against politically controversial issues, undesired readers, or Marxist philosophers.[16] The persecution framework, however, not only has some internal inconsistencies, such as the role of Sofia Yanovskaia and Aleksandr Khinchin, the key figures in the emerging field, in the public campaign against their colleague and the leader of the Moscow school of mathematics, Nikolai Luzin. More pragmatically, it also gets in the way of a reflection on the intellectual content and methodology relevant to the Soviet interpretation of the legacy of al-Khwarizmi.[17] The classical Soviet accounts of Arabic-language mathematics point to intersections and similarities in the intellectual output produced by the victims of state repression and that produced by its perpetrators. If there is no doubt that ideology shaped the agenda and practices of Soviet mathematicians and historians of mathematics, the question remains: how so?[18]

Among the most influential early Russian-language works on al-Khwarizmi that would eventually attract the attention of the computer scientists are the 1954 paper by A. P. Yushkevich "Arifmeticheskii traktat Mukhammeda Ben Musa Al Khwarizmi" and the 1964 edition of al-Khwarizmi's mathematical manuscripts edited by Iu. Kopelevich and B. A. Rozenfel′d.[19] Yushkevich's name was familiar to many Western historians of science in the last decades of the Soviet Union (and still is), as he frequently traveled to the West—he did so, for example, for his numerous international collaborative projects on Leonhard Euler.[20] Yushkevich was considered not so much an Orientalist as the major Soviet authority on mathematics in general and medieval mathematics in particular, thanks to the numerous translations of his monumental book *History of Mathematics in the Middle Ages*.[21] This monograph gained lasting international renown for its unprecedented synthetic treatment of Arabic mathematics, itself a result of the book's

[16] Sergei S. Demidov, "Russia and the USSR," in *Writing the History of Mathematics: Its Historical Development*, ed. Joseph W. Dauben and Christoph J. Scriba (Basel: Birkhäuser, 2002), 179–97.

[17] The Luzin affair deeply marked the internal memory of the Moscow mathematical community and historians still debate its causes and consequences; see Aleksey E. Levin, "Anatomy of a Public Campaign: 'Academician Luzin's Case' in Soviet Political History," *Slavic Review* 49, no. 1 (1990): 90–108; S. S. Demidov and B. V. Levshin, eds., *Delo akademika Nikolaia Nikolaevicha Luzina* (St. Petersburg: RKhGI, 1999); S. S. Kutateladze, "Roots of Luzin's Case," *Journal of Applied and Industrial Mathematics* 1, no. 3 (2007): 261–67; Loren Graham and Jean-Michel Kantor, *Naming Infinity: A True Story of Religious Mysticism and Mathematical Creativity* (Cambridge, MA: Harvard Univ. Press, 2009).

[18] Such questions are in line with scholarship emphasizing the need to normalize Soviet experiences and attribute agency to practitioners; see Nikolai Krementsov, *Stalinist Science* (Princeton, NJ: Princeton Univ. Press, 1997); Alexei B. Kojevnikov, *Stalin's Great Science: The Times and Adventures of Soviet Physicists* (London: Imperial College Press, 2004); and Asif A. Siddiqi, *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857–1957* (New York: Cambridge Univ. Press, 2010).

[19] A. P. Yushkevich, "Arifmeticheskii traktat Mukhammeda Ben Musa Al-Khorezmi," *Trudy IIET* 1 (1954): 85–127; al-Khwarizmi, *Matematicheskie traktaty*. Yushkevich's analysis lost some of its relevance in the 1990s, when the new versions of the Latin translations were discovered; see Menso Folkerts and Paul Kunitzsch, eds., *Die älteste lateinische Schrift über das indische Rechnen nach al-Ḫwārizmī* (Munich: Verlag der Bayerischen Akademie der Wissenschaften, 1997).

[20] For an example see N. N. Bogolyubov, G. K. Mikhailov, and A. P. Yushkevich, eds., *Euler and Modern Science*, trans. Robert Burns (Washington, DC: Mathematical Association of America, 2007).

[21] A. P. Yushkevich, *Istoriia matematiki v srednie veka* (Moscow: GIFML, 1961). This monograph was translated into Romanian (1963), German (1963), Polish (1969), Japanese (1971), French (1976), Czech (1977), and Hungarian (1983).

distinct methodology based on a systematic comparison and establishment of links between regions and civilizations.[22]

This methodological emphasis on comparison and circulation grounded the role of the algorithm. In the book, Yushkevich used this methodological emphasis to support his main arguments presenting the unity and coherence of medieval mathematics as distinct from that of antiquity, a controversial thesis for the 1960s. The Soviet scholar debated these ideas in print and private exchanges. For instance, in a 1957 letter to the German historian of mathematics Kurt Vogel, he insisted that his position regarding the algorithmic nature of Oriental mathematics differed from that taken by most Western historiography, which emphasized the Greek tradition: "Although Arabic mathematicians were students of the ancient Greeks, they created a science that was different from the classical one. The mathematics of Arabs, Iranians, Tajiks, and so on in the Middle Ages is a branch of the algorithmic mathematics of the ancient and medieval East."[23]

While Yushkevich's thinking on algorithmic mathematics was international in its reach, in the Soviet context, his *History of Mathematics in the Middle Ages* was to be part of a multivolume work presenting a history of mathematics up to the nineteenth century. Ultimately, only two volumes would come out. The book's subtitle read "Mathematics before the Renaissance" and signaled that it was a follow-up to *The History of Mathematics in Antiquity*, by the philosopher Ernst Kolman. The chronological organization of the two-volume project was also explained in an introduction cosigned by the respective authors. The scholars stated that their history of mathematics was written from the Marxist standpoint and that the goal of the volumes was to "study the historical development of mathematical terms, methods and algorithms, accounting when possible for the tendencies of contemporary science."[24] One such tendency the book provides as an example is the ascent of numerical mathematics, the branch made particularly relevant by the computer and genealogically connected, in the eyes of Soviet historians, to the history of the ancient and medieval East.

The historical interest of this introductory text for understanding how ideology shaped practice goes beyond its direct statements. Yushkevich's collaborator, Kolman, was a key protagonist of one of the most infamous episodes associated with the Stalinist regime's impediment of the autonomy of expert communities, penning numerous accusation reports on Luzin in the 1930s.[25] It turned out that by the late 1950s, Yushkevich and Kolman had to collaborate as employees of the Institute for the History of Natural Sciences and Technology.[26] This historical conjuncture sheds additional light on the role of Marxist philosophy in shaping the intellectual stakes of the Soviet history of mathematics. These intellectual stakes, and their associated practices, transcend both the simplified roles of victims and perpetrators in the Stalinist campaigns and the political chronology of the Thaw.

[22] Karine Chemla, "Les travaux de A. P. Youschkevitch sur l'histoire des mathématiques en Chine," in *Studies in History of Mathematics Dedicated to A. P. Youschkevitch, Proceedings of the XXth International Congress of History of Science, Liège (Belgium), 20–26 July 1997*, ed. Eberhard Knobloch, Jean Mawhin, and Serguei S. Demidov (Liège: Brépols, 2002), 25–31.

[23] A. P. Yushkevich, *Istoriia matematiki bez granits: Nauchnaia perepiska* (Moscow: Ianus, 1997), 66.

[24] Yushkevich, *Istoriiamatematiki bez granits*, 8.

[25] Demidov and Levshin, *Delo akademika Nikolaia Nikolaevicha Luzina*.

[26] On institutional politics, see S. S. Ilizarov, "Ernest Kolman, Nikita Khrushchev i IIET," *Voprosy istorii estestvoznaniia i tekhniki* 28 (1998): 152–56.

In his 1991 interview with Karine Chemla, Yushkevich explained the genesis of his work on medieval mathematics as a series of research projects driven by the state order. For example, his classic monograph on medieval mathematics was an institutional project that came with a full-time position as a historian. This position contrasted with Yushkevich's earlier part-time research in history on top of teaching mathematics, and was itself a role forced upon him when he was prevented from teaching during the infamous anticosmopolitan campaign of Stalin's final years.[27]

Whereas Yushkevich's story was one of the triumph of ingenuity and creativity over the abuses of Soviet authoritarianism, his colleague's path to the Institute for the History of Natural Sciences and Technology was no less twisted. Known by the sobriquet Dark Angel, which he earned as the perpetrator of abuses such as the Luzin affair, Kolman was a mathematician turned revolutionary, then philosopher, then political prisoner, and ultimately apologist of cybernetics and professional historian. He would eventually defect to Sweden to write a dissident autobiography.[28] Because Kolman's name is often mentioned in connection with his intrigues—politicking and dissent—his views on the philosophy and history of knowledge attracted little attention until a recent reassessment by Michael Gordin.[29] Kolman's ideas about mathematical knowledge are of particular relevance here, as, the striking differences in life trajectory between the two authors of *The History of Mathematics before the Renaissance* notwithstanding, their visions of the history of mathematics were not unlike.

In response to Chemla's question about the aims of the history of mathematics, Yushkevich began by pointing out the pedagogical role of history in shaping the mindset of mathematical practitioners: "History may serve to explain the subject of mathematics to its students, explaining the evolution of the very subject of mathematics in time and in a sense in historico-regional spaces. The study of mathematical disciplines entails specialization, but despite the specialization it is crucial to see the interconnections in their dynamic variation from period to period, from one social or national milieu to another."[30]

This emphasis on the historical approach to the subject of mathematics and its dialectic "unity in variety" has a strong parallel in the agenda for the history of mathematics articulated by Kolman back in the early 1930s. One representative text of Kolman's from this period is "The Present Crisis in the Mathematical Sciences and General Outlines for Their Reconstruction," which he presented at the London Congress of the History of Science and Technology in 1931.[31] As its title suggests, the paper outlined a socialist solution to the crisis in the foundations of mathematics in connection with the late nineteenth-century development of set theory. Kolman's version of such a solution emphasized not only the expected dialectic of "theory and practice" but also "the unity

[27] A. P. Yushkevich, "Interv´iu zapisannoe Karine Chemla," in *40 let Institutu istorii estestvoznaniia i tekhniki* (Moscow: VIET, 1994), 26–42, 35.

[28] E. Kolman, *My ne dolzhny byli tak zhit'* (New York: Chalidze, 1982).

[29] Michael D. Gordin, "The Trials of Arnošt K.: The Dark Angel of Dialectical Materialism," *Historical Studies in the Natural Sciences* 47, no. 3 (2017): 320–48.

[30] Yushkevich, "Interv´iu," 41.

[31] E. Colman [Kolman], "The Present Crisis in the Mathematical Sciences and General Outlines for Their Reconstruction," in *Science at the Cross Roads: Papers Presented to the International Congress of the History of Science and Technology Held in London from June 29th to July 3rd, 1931, by the Delegates of the U.S.S.R.* (London: Kniga, 1931); the electronic version of the text is available at https://www.marxists.org/subject/science/essays/colman3.htm.

of the historical and the logical."[32] Calling on history for educating socialist mathematicians, he outlined a comprehensive research plan that included the main mathematical concepts, classifications, intellectual relations between subfields and practices, and even "neglected" branches of mathematics. In short, Kolman aimed to contribute a vision of the future of mathematics by relying on historical research that would cover all aspects of the development of the dynamic structure of mathematical sciences as a whole.

This striking similarity in both the goals and the main objects of the history of mathematics across several decades—from the 1930s through the 1960s and then to the 1990s—indicates that the Marxist framework was not a hollow system of references aimed at Soviet censors and signals that its impact on the self-perception and agenda of Soviet historians of mathematics in general requires a careful examination.[33] More immediately, the integration of the Marxist dimension clarifies the interactions between historians of mathematics and mathematicians, a key step in tracing how the nascent discipline of computer science came to locate the origins of the algorithm in Uzbekistan.

The crisis mentioned in Kolman's paper was connected to debates about the nature of mathematical knowledge that became associated with positivism, intuitionism, and formalism, all familiar in Soviet Russia thanks to translations of major works as well as personal connections, such as those maintained between Yanovskaia and the philosopher Ludwig Wittgenstein.[34] In postrevolutionary Moscow, Khinchin's and Yanovskaia's seminars at Moscow University and the Communist Academy were sites of engagement, on the part of Soviet mathematicians, with these ideas; it was at these two institutions that the consequences of dialectical materialism for mathematics would be debated. A combination of social and intellectual factors, on the spectrum between the pragmatics of patronage and the abstractions of epistemology, came to define the practices of mathematical historians working on algorithmic mathematics and influence the way that the Soviet specialists in computing were to engage with their work.

The key Soviet mathematician with tremendous influence over both historians and computer scientists was Andrei Kolmogorov. A mathematical prodigy, young Kolmogorov not only witnessed the debate over the nature of mathematics but also contributed a paper on the law of the excluded middle and intuitionism in 1925.[35] Two major lines of the investigation were to grow out of this early interest—one in mathematical logic, resulting in a much later engagement with the notion of algorithm, and one in the history of mathematics. The first would eventually influence how the work of the historians was received by practicing computer scientists, but it was the second that would have immediate consequences for the history of mathematics.

[32] Colman, "Present Crisis."

[33] A shared framework, however, does not determine the quality and intellectual ambitions of historical work. For instance, Kolman in fact pioneered research on Central Asian mathematics during World War II, but his work was in the genre of antifascist propaganda and did not attempt the historiographic revision conducted later by Yushkevich. See E. Kolman, *Velikie dostizheniia drevneaziatskoi kultury i kak fashizm tuzhitsia ikh sebe prisvoit'* (Alma-Ata: KazOGIZ, 1942).

[34] B. V. Biriukov and L. G. Biriukova, "Ludwig Wittgenstein i Sof'ia Aleksandrovna Ianovskaia: ′Kembridzhskii genii znakomitsia s sovetskimi matematikami 30kh godov," *Logicheskie issledovaniia* 11 (2004): 46–95.

[35] A. N. Kolmogorov, "O printsipe tertium non datur," *Matem. Sbornik* 32, no. 4 (1925): 646–67; Kolmogorov, "Sovremennye spory o prirode matematiki," *Nacuhnoe slovo* 9 (1929): 41–54; and Kolmogorov, "Zur Deutung der intuitionistischen Logik," *Mathematische Zeitschrift* 35 (1932): 58–65.

Kolmogorov, with whom Yushkevich frequently collaborated, devoted more than twenty publications to the history and philosophy of mathematics over the course of his career.[36] Kolmogorov's most influential contribution to the development of a historical approach in defining the subject of mathematics was the programmatic article "Mathematics," which appeared in the first edition of *The Great Soviet Encyclopedia* (1938).[37] In this article Kolmogorov put forward a four-stage chronology of the discipline that would be reproduced in most Soviet historical narratives for many years to come, including Kolman's and Yushkevich's volumes. Best described as dialogical and cooperative, the relationship between the mathematician and the historian sheds light on how patronage and personal networks cemented institutional developments and grounded the production of historical knowledge about Arabic-language mathematics in Russian.[38]

In the postwar years, in addition to the university's training of specialists in the history of mathematics, the Institute for the History of Natural Sciences and Technology reopened in Moscow, providing an important organizational base. This institution employed historians of mathematics and offered diffusion outlets where the pioneering Soviet publications on Arabic-language mathematics would eventually appear.[39] The flourishing interest in Central Asian mathematics was strongly correlated with World War II and the evacuation of many researchers to the region. But the sustained character of the geographical expansion of the field was predicated on a structural feature: by the 1960s the history of mathematics became a compulsory subject in the university curriculum of the mathematics departments.[40] The location of employment opportunities was significant. The individual biographies of Soviet historians of mathematics show different trajectories, but they converge in illustrating that the patterns of movement from mathematics to the history of the subject reflected a general dependency of scales: the history of mathematics grew as the offshoot of a dramatic growth in the field of mathematics itself.[41] Despite the social and epistemic hierarchies underlying the relationship between the two communities, the influence of mathematicians on historians was not unidirectional but rather a reciprocal and constructive one.

[36] A. P. Youshkevitch [Yushkevich], "A. N. Kolmogorov: Historian and Philosopher of Mathematics. On the Occasion of His 80th Birthday," *Historia Mathematica* 10, no. 4 (1983): 383–95.

[37] A. N. Kolmogorov, "Matematika," in *Bol'shaia sovetskaia entsiklopediia*, vol. 8, 2nd ed. (Moscow: Bol′shaia sovetskaia entsiklopediia, 1938), 359–402.

[38] Kolmogorov attracted Yushkevich to his team as the chief editor of the mathematical section in the second edition of *The Great Soviet Encyclopedia* (1949–1958); numerous editorials would also see the two frequently serve as coeditors. The decades-long cooperation would eventually lead to the two collaborating on a project that was of personal importance to both: a translation of Georg Cantor's works on set theory. Cantor, *Trudy po teorii mnozhestv*, trans. F. A. Medvedev and P. S. Yushkevich (Moscow: Nauka, 1985). The first Russian-language translations of Cantor's works were by P. S. Yushkevich (1914), the father of the historian. For Kolmogrov, the translation project was the realization of a plan initiated by the deceased P. S. Alekandrov.

[39] The most important series were those series edited by IIET, *Trudy IIE* and later *IIET*, and *Istoriko-Mathematichekie Issledovaniia* (*IMI*), based on the works of the Moscow University seminar on the history of mathematics. On the role of this journal in the scholarship on Arabic-language mathematics, see Liuter, "Stanovlenie sovetskoi shkoly."

[40] K. A. Rybnikov, *Istoria matematiki*, 2 vols. (Moscow: Zd-vo Mosk. Universiteta, 1960–1963).

[41] See Boris Rozenfel′d, "Prostranstva, vremena, simmetrii. Vospominaniq i mysli geometra," http://www.rulit.me/books/prostranstva-vremena-simmetrii-vospominaniya-i-mysli-geometra-read-240604-1.html. The career of Mark Vygodskii is another illustrative example; see S. S. Demidov, S. S. Petrova, and T. A. Tokareva, "Mark Iakovlevich Vygodskii—matematik, istorik matematiki i pedagog (k 50-letiiu so dnia smerti)," *Chebyshevskii Sbornik* 16 (2015): 319–46.

These blurry institutional and intellectual boundaries between practitioners and historians of mathematics were manifested in the orientation of historical narratives that explained features of modern mathematics. The postwar increase of interest in theory of algorithms, as represented in the works of A. A. Markov Jr. and Kolmogorov, and the growth of works on Arabic-language "algorithmic" mathematics were certainly parallel developments operating on a shared intellectual terrain shaped by the shared engagement with humanist values, moral commitments, and sociability of "intelligentsia logics."[42]

Later, the availability of the Soviet works on Arabic-language mathematics was in itself an important asset for the computer scientists who were exploring past mathematical practices in order to develop an identity for their new discipline. The appeal of these Soviet publications for computer science pioneers had to do with an affinity for the historians' ideas about the dynamic universality of mathematical knowledge and their emphasis on the algorithm. Such affinity notwithstanding, professionalization also meant distinct forms of authority and diverging agendas. The printed texts consulted by computer experts were not locked into the disciplinary framework of their production and were open for interpretation.

The limits of the dialogue and the derivative status of the historical narrative in the eyes of computer scientists were most obvious in the choices of the Soviet organizers of the 1979 symposium "Algorithms in Modern Mathematics and Computer Science," held in Urgench. Interested in the power of history, they drew on the Soviet historiography of algorithmic mathematics but invited no historians despite several suggestions. In fact, the computer scientists turned not to historians but to Kolmogorov's mathematical descendants. The goal of the computer scientists' pilgrimage to Uzbekistan was less about locating the cradle of the algorithm per se than in fostering a community around the shared symbols that they appropriated from the Soviet historical works. The longest paper in the conference proceedings was by two representatives of Moscow University's *kafedra* (a small subdepartmental unit) in mathematical logic, a unit that grew out of Yanovskaia's kafedra in history and philosophy of mathematics. Vladimir Uspenskii and Aleksei Semenov asked: "What are the gains of the theory of algorithms?"[43] In the end, the big question for the computer scientists was not about the algorithm as a historical object but as a legitimate subject of their discipline.

PART 2. SEARCHING FOR ORIGINS

The fact that the key figures of the American efforts to establish a separate identity for computer science, such as Donald Knuth, turned to history in the process of doing so is less puzzling than the Soviets hosting an event devoted to the origins of the algorithm. A short overview of computer developments focusing on a disciplinary evolution—and not on hardware—in the Soviet Union explains the improbable location of the Urgench meeting. The Computer Centre of the Novosibirsk science-city known as Akademgorodok was an essential node in enabling international connections with Stanford University, one of the key players in the institutionalization of computer science. But

[42] A. A. Markov, "Teoriia algorifmov," *Trudy Matem. in-ta im. Steklova* 38 (1951): 176–89; A. N. Kolmogorov, "O poniatii algoritma," *UMN* 8 (1953): 175–76.

[43] V. A. Uspenskii and A. L. Semenov, "What Are the Gains of the Theory of Algorithms: Basic Developments Connected with the Concept of Algorithm and with Its Application in Mathematics," in Ershov and Knuth, *Algorithms*, 100–234.

neither personal nor institutional networks alone account for the agenda of the Urgench meeting: to consolidate algorithms as the core of the new discipline and to integrate the multiculturalism described in Soviet historical works into the community's values. Although computer science would eventually become associated with another father figure, British mathematician Alan Turing, the search for origins in the 1970s reveals transnational processes at play in consolidating authority and epistemic universalism during the first two decades of building the discipline.

From the early postwar efforts to the 1979 international conference, the Cold War context of computing didn't exclusively reflect the divisions evoked by the proverbial Iron Curtain. The earliest, secret Soviet computer developments were intrinsically connected to the Western ones, all while Soviet media were publicly criticizing militarism and imperialism of cybernetics in the West. A wave of major changes followed the public recognition of the existence of Soviet digital computers, which was first announced at the international conference Elektronische Rechenmaschinen und Informationsverarbeitung (Electronic Digital Computers and Information Processing) held in the fall of 1955 in Darmstadt, West Germany. During the late 1950s the status of cybernetics in the Soviet Union had radically altered, from that of a bourgeois pseudoscience to a metadiscipline at the service of Communism.[44] But by the end of the next decade, the heyday of cybernetics was over and the Soviet programming community was looking to establish an independent disciplinary identity. The leaders of this community struggled for a recognized institutional structure to house the study of the theoretical aspects of computing. Andrei Ershov, one of the first mathematicians to be trained as programmers at the Moscow State University in the 1950s, became a spokesperson of the effort, promoting the establishment of a new field of theoretical programming.[45] Ershov envisioned this field as separate from the umbrella discipline of cybernetics and not subservient to mathematical logic. He also explicitly called for modeling it on the American-born discipline of computer science. The connections between this Soviet domestic development and the international ones were not fortuitous but rooted in the system of transnational exchanges operating bilaterally and multilaterally through major academic institutions and professional societies.[46]

One of the key Soviet mediators, Ershov—who was well integrated in the international professional networks—was particularly close to Stanford researchers and the disciplinary visions promoted by George Forsythe, the creator and first chair of Stanford's Computer Science Department as well as the president of the main professional body gathering American computer experts, the Association for Computing Machinery (ACM). Ershov served as the main intermediary between his American coorganizer, Knuth, and the Uzbek hosts of the 1979 event. That Ershov, the head of the programming department at the Akademgorodok Computer Centre, was located in Siberia was not a hindrance. On the contrary, the showcase status of the science-city facilitated transnational connections.[47]

[44] Slava Gerovitch, *From Newspeak to Cyberspeak: A History of Soviet Cybernetics* (Cambridge: MIT Press, 2002).

[45] Irina Kraineva and Natalia Cheremnykh, *Put' programmista* (Novosibirsk: Nonparel′, 2011).

[46] Ksenia Tatarchenko, "Not Lost in Translation: How Did English Become the Common Language of Information Processing (1960–1974)?" (paper presented at Software for Europe Workshop, Lorentz Center, Leiden, The Netherlands, September 2010).

[47] Ksenia Tatarchenko, "Calculating a Showcase: Mikhail Lavrentiev, the Politics of Expertise, and the International Life of the Siberian Science-City," *Historical Studies in the Natural Sciences* 46, no. 5 (2016): 592–632.

The first initiative for a commemorative trip came not from Ershov but from Knuth.[48] In fact, even though the Americans had a discipline, computer science, they still had to struggle to define a set of problems, curricula, and boundaries proper to it. When Knuth joined the Stanford Computer Science Department in 1968 he came with an agenda to develop the analysis of algorithms as an academic subject, and would later claim this to be his proudest achievement.[49] According to Knuth, if he had had a chance to vote for a name, and by the same token the agenda, for his discipline, he would have chosen "algorithmics," the term coined by Joseph F. Traub.[50] In 1974, Knuth was awarded the ACM Turing Award for his work *The Art of Computer Programming*, which is still considered one of the fundamental texts of computer science. As one might expect, this work opens with a historical exploration of the origins of the term based on early twentieth-century historical publications.[51] In his 2016 essay review of the algorithm's historiography, Maarten Bullynck argues that Knuth, in his 1972 paper on ancient Babylonian algorithms, had already brought the tools and concepts of computer science into the classical part of the history of mathematics and used Otto Neugebauer's authority to connect the new discipline to the great tradition of the Göttingen school.[52] In any case, by the late 1970s Knuth came to locate the cradle of the algorithm not in ancient Babylonia but in medieval Khwarezm, a shift that reveals the American computer scientist's preoccupation with community building.

In his speech at the 1979 symposium, Knuth admitted that he had "wanted to make a pilgrimage to this place for many years, ever since learning that the word 'algorithm' was derived from the name of al-Khwârizmî, the great ninth-century scientist whose name means 'from Khwârizm.'"[53] The meeting site—Urgench, located in the Uzbek SSR—therefore had particular significance and a visit to such a place was the dream of any mathematician, from the most "pure" to the most "applied" types. Framing the symposium as a pilgrimage corresponded to hefty ambitions associated with the gathering.[54] Knuth's choice to embrace al-Khwarizmi's identity as a "Khwarezmian"—emphasized in numerous Soviet works propelling the general message about the actuality of algorithmic mathematics of the Middle East—resonated with his future-oriented disciplinary goals encompassing intellectual and moral dimensions. Knuth and other participants of the Urgench meeting viewed themselves as representing an algorithmic community and creatively drew on Western and Soviet historical publications to depict the medieval scholar as a "universalist" and to imagine the Central Asian oasis as the cradle of "algorithmic thinking."

[48] Donald Knuth, "An International Symposium on Algorithms in the Soviet Union (91/97)," https://www.youtube.com/watch?v=sYpthgi6x1U. The correspondence preserved at the Ershov Archive confirms the version in Knuth's recollections.

[49] An overview of Knuth's biography is available at the ACM's Turing Awards list, David Walden, "Donald ('Don') Ervin Knuth," *ACM A. M. Turing Award*, https://amturing.acm.org/award_winners/knuth_1013846.cfm.

[50] Donald Knuth, "Algorithms in Modern Mathematics and Computer Science," in Ershov and Knuth, *Algorithms*, 82–99.

[51] Donald Knuth, *The Art of Computer Programming*, 3 vols. (Reading, MA: Addison-Wesley, 1968–1973).

[52] Maarten Bullynck, "Histories of Algorithms: Past, Present, and Future," *Historia Mathematica* 43, no. 3 (2015): 332–41.

[53] Knuth, "Algorithms in Modern Mathematics," 82.

[54] Ershov and Knuth, introduction to *Algorithms*, i–iv.

Heinz Zemanek, the Austrian computer pioneer, who happened to be passionate about history and became enchanted with Arabic-language mathematics after an earlier visit to Uzbekistan, contributed a lengthy description of al-Khwarizmi's life and oeuvre to the symposium. He didn't claim that the scholar invented the algorithm. Rather, Zemanek used the medieval formula *dixit Algorismi* [so says al-Khwarizmi] to directly engage with historical sources and demonstrate their clarity and reliability as foundations of the medieval scholar's authority. Analogy allowed Zemanek to invert the flow of time and to claim that al-Khwarizmi's "abstractions are as operational and goal-oriented as the abstractions which are used for, and are running, the computers of our own century."[55] In the same logic, Zemanek concluded his contribution with an abrupt leap from the Middle Ages to the twentieth century, from al-Khwarizmi to the Dutch computer scientist Edsger W. Dijkstra, and, in particular, Dijkstra's professional ideals and goals for software engineering.[56]

Even before M'Bow's 1983 declaration celebrating multiculturalism, Zemanek ended his contribution with a depiction of the mathematician's legacy as the epitome of morality and an embodiment of intercultural synthesis:

> I think that we computer scientists of the 20th century, in particular the algorithmic community, have quite a lot to learn from al-Khorezmi's method and success. . . . Al-Khorezmi teaches the programmer humbleness a thousand years before Dijkstra and reminds us that we are servants of our society just as he was a servant of caliph. In the metropolis of Baghdad not only many nations cooperated for a common goal; certain men, like al-Khorezmi, achieved an alloy of cultures. . . . We can end here with only one wish: that in a thousand years our rediscoverers will look at what has remained of us with the same respect with which we are looking back today on al-Khorezmi and his colleagues in the House of Wisdom.[57]

Despite the similarity in emphasis on moral qualities and intercultural connections, Zemanek's notion of humility itself was radically different from that employed by M'Bow. In the context of computing, "humbleness" referred to particular technical choices in designing programming languages, the ongoing debates about the epistemic boundaries of the new professional expertise associated with the computer, and the title of Dijkstra's speech upon receiving the Turing Award in 1972: "The Humble Programmer."[58]

The documents generated by the symposium indicate that the distant past was not the only aspect of history available to the community that gathered in Urgench. The computer scientists and mathematicians in attendance also drew upon two other genres of historical projection frequently used by scientists; namely, personal recollections and the history of ideas. But discussing the legacy of al-Khwarizmi was, in a sense, a safer topic than debates over professional priorities or even committing to defining the algorithm itself. If there was a general consensus among the attendees that the algorithm

[55] Heinz Zemanek, "DIXIT ALGORIZMI. His Background, His Personality, His Work, and His Influence," in Ershov and Knuth, *Algorithms*, 79.

[56] Ed Dijkstra was initially enthusiastic to attend but ended up refusing the invitation, despite close personal ties with Ershov. Dijkstra to A. P. Ershov, October 22, 1978, f. 384/ l. 200–1, Ershov Archive, hosted by A. P. Ershov Institute of Informatics Systems of the Siberian Branch of the Russian Academy of Sciences, http://ershov.iis.nsk.su/en/.

[57] Zemanek, "DIXIT ALGORIZMI," 80–81.

[58] Edsger W. Dijkstra, "The Humble Programmer," *Communications of the ACM* 15, no. 10 (1972): 859–66.

was one of the basic concepts of mathematics, its formal definition was, and still is, an open challenge.[59]

Stephen Kleene, then seventy years old, was the doyen of the meeting. He had many stories to tell: as a student of Alonzo Church at Princeton in the 1930s, he worked on Church's lambda calculus and later, at the turn of the decade, laid the foundations for recursion theory. Although the text of his recollections shared on the last evening of the symposium was not published in the proceedings, the volume contains his paper on algorithms framed as a series of reactions to statements of other participants, circulated in advance of the meeting. According to Kleene, the famous early twentieth-century crisis of foundations of mathematics and the *Entscheidungsproblem* are best understood thanks to the old idea of algorithms, which he describes as a procedure following a finite set of rules to answer a given infinite class of questions.[60]

This understanding of the algorithm is in fact rather common. Another participant of the symposium also described the algorithm as a list of instructions specifying a sequence of operations that will give the answer to any problem of a given type, such as the four arithmetic rules for decimal numbers formulated by al-Khwarizmi.[61] But the formal descriptions of the algorithm didn't spontaneously follow the intuitive ones. In the words of Soviet logicians Uspenskii and Semenov, who presented a historical overview of the theory of algorithms at the symposium, the algorithm possesses features of an independent and primary notion that cannot be defined within other standard notions of mathematics: "The development of the theory of algorithms meets the difficulty provoked by the fact that the algorithms themselves are objects of a very special kind and have property non-typical for mathematical objects—the semantic property 'to have a meaning.' . . . The meaning of an algorithm is imperative: an algorithm is to be performed. . . . The theory of algorithms can be treated as a linguistics of imperative sentences. Mathematicians have not yet found out how to do properly with the linguistic objects filled with meanings."[62]

The fundamental differences in approach to the algorithm adopted by different papers presented does not signal the failure of the symposium. Rather, the multiplicity of voices was legitimated by the historical character of the site and encouraged by design, beginning with the circulation of "provocative questions" and offering a free format for contributions. The organizers achieved at least one of their primary goals: to provoke a discussion by questioning the most basic categories of their disciplines.

The goal of consolidating the status of al-Khwarizmi as the father figure of the discipline turned out to be out of reach. The Soviet invasion of Afghanistan leading to international tensions is among possible contextual reasons. Another is the evolution of

[59] See Yiannis Moschovakis, "What Is an Algorithm?," in *Mathematics Unlimited—2001 and Beyond*, ed. Björn Engquist and Wilfried Schmid (Berlin: Springer, 2001), 919–36; Yuri Gurevich, "What Is an Algorithm?," in *SOFSEM 2012: Theory and Practice of Computer Science*, ed. Mária Bieliková et al. (Berlin: Springer, 2012), 31–42.

[60] Stephen C. Kleene, "Algorithms in Various Contexts," in Ershov and Knuth, *Algorithms*, 355–60; and Kleene, "Origins of Recursive Function Theory," *Annals of the History of Computing* *3*, no. 1 (1981): 52–67. Kleene's classic work on recursive functions was translated into Russian and familiar to the Soviet participants of the symposium as it was edited by Uspenskii; see Kleene, *Introduction to Metamathematics* (Princeton, NJ: D. Van Nostrand, 1952); *Vvedenie v metamatematiku*, ed. V. A. Uspenskii, trans. A. S. Esenin-Vol′pin (Moscow: Iz-vo instrannoi literatury, 1957).

[61] See B A. Trakhtenbrot, "Algorithms (1960)," in *Perspectives on the Computer Revolution*, ed. Zenon W. Pylyshyn, Liam J. Bannon, 2nd ed. (Norwood, NJ: Ablex, 1989), 203–22.

[62] Uspenskii and Semenov, "What Are the Gains," 100–101.

the community's historical commitments. As examined by Edgar Daylight, Maarten Bullynck, and Liesbeth De Mol, Turing was progressively presented as the source of origin in the genealogy of the discipline.[63] Although naming the ACM award the Turing Award in 1966 corresponds to a first formal recognition of his status, the key shift in perception took place later, in connection to the disclosure of Turing's wartime works during the 1970s and following the publication of the biography by Andrew Hodges in 1983.[64]

This subsequent intellectual oblivion of the lofty agenda of the meeting by the discipline doesn't take away individual experiences of a real-life encounter with Soviet Uzbekistan as documented by the photographic evidence, the publications in the local press, and personal accounts. According to British computer scientist Mike Patterson, the week was made delightful and unforgettable thanks to an "exuberant welcoming" and the hospitality of the people and institutions that was nothing short of "overwhelming."[65] Although a full engagement with the distinct Soviet aspect of the commemoration that transpires in such descriptions is beyond the scope of this study, it is essential to acknowledge that Soviet national as well as republic-level and local interests were crucial for both the experiences of the participants and the long-term influences of the event. The intersection of such interests helps with gauging the role of the academic experts in wider, social aspirations to connect the algorithmic past to digital futures.

"Your region," Knuth told journalists from the Urgench newspaper *Khorezmaskaiia Pravda*, "should become the mecca for all information technology specialists."[66] This high praise was predicated on a particular vision of what computing was about: playing with a reference to the base ingredient of any processor, silicon, Knuth reminded the readers that computers are made of sand and accomplish intelligent tasks thanks to programs—which was to say, thanks to algorithms. But this hierarchical geography of the computer world as imagined by the American coorganizer of the event was not only unusual in the sense that it reversed the already established stereotype of Silicon Valley as the center of the computer industry; it was also a particularly generous and well-received compliment directed at the hosts and the efforts they had dedicated to making the meeting possible.

Indeed, local hosts spared no efforts at making the event memorable. Participants were wined and dined by the region's elites and feasts were accompanied by traditional dances; on one occasion Knuth even shared the dance floor with an Uzbek performer. Scientists enjoyed a visit to a rice farm named after al-Khwarizmi and were taught how to pick cotton, toured museums and minarets, took pictures of camels and bought Uzbek hats, *tubeteika*, as souvenirs. When the international group of scientists left the city, their attention turned to preparing the conference proceedings, and many material and intangible results of the encounter remained behind.

If the scientific conference was indeed a transient event, it partook in the long regional efforts at memory construction that would eventually culminate in UNESCO's support of al-Khwarizmi's anniversary celebration and gain new momentum with the

[63] Maarten Bullynck, Edgar G. Daylight, and Liesbeth De Mol, "Why Did Computer Science Make a Hero out of Turing?," *Communications of the ACM* 58, no. 3 (2015): 37–39.
[64] Andrew Hodges, *Alan Turing: The Enigma* (New York: Simon and Schuster, 1983).
[65] Mike Patterson, "Report," *Bulletin of the European Association for Theoretical Computer Science* 10 (1980): 63–64, f. 191/ l. 17, Ershov Archive.
[66] D. Knuth, "V Poiske," *Khorezmskaia Pravda*, September 25, 1979, f. 191/ l. 134, Ershov Archive.

establishmentof an independent Uzbekistan in the aftermath of the Soviet Union's collapse. But, as the choice of Moscow as the location for the 1983 commemorative ceremony indicates, the association between memory and belonging was a two-way street, encompassing both the regional and the metropolitan agendas. The 1983 anniversary became an occasion to foster the Soviet enlightenment ideal on the all-Union scale, connecting the Uzbek algorithmic heritage to the education of model citizens by means of the popular scientific press. In the mid-1980s, this genealogy would be instrumentalized on a much larger scale. Numerous Soviet publications mentioned al-Khwarizmi alongside the notion of the algorithm in connection to the computer literacy campaign led by Ershov and formulated around the idea of algorithmic thinking. As a result, unlike the Western computer scientists who eventually settled on a different father figure, the last Soviet generation came to associate the medieval scholar and computer algorithms as a standard cultural reference.

Searching for origins is an ongoing project among the constituency of information technologies experts in the post-Soviet regions. The home web page of the 14th International Conference on the Application of Information and Communication Technologies (AIST), which was supposed to be held in Urgench and Tashkent in the fall of 2020, used Knuth's international reputation to pledge that the event was to be devoted to al-Khwarizmi's scientific heritage. Stating that "Al Khwarizmi is the man who invented algorithms," and inviting "every computer scientist to whom the word 'algorithm' makes great sense" to join this new scientific pilgrimage,[67] the gathering was imagined as a space transcending the divisions of theory and practice, of code and craft as "a forum to bring together business people, researchers, scientists, software architects, and industry professionals to discuss innovative ideas and diverse topics on the next generation of information technologies and services."[68] The organizers' capacity to deliver on their promise of tomorrow's information technologies is of lesser importance than another practical and future-oriented goal; namely, the pedagogical one. Their plans to hold a summer school and workshop titled "From al-Khwarizmi to Machine Learning" for local university students demonstrate the reproduction and malleability of the late Soviet claims on the algorithm's history. By the same token, they remind us that mapping non-Western geographies of the algorithm's rise invites grappling with its Soviet and post-Soviet political and cultural heritage.

CONCLUSIONS

Laying claims to al-Khwarizmi's legacy didn't depend on the strength of a national computer industry nor on the ideological ambitions of the party-state. Rather, this was a matter of interest to different communities. First, al-Khwarizmi's legacy was claimed by the Soviet historians of mathematics who translated and published his works, who revisited and reinterpreted his scholarship in light of a Marxist history of mathematics. The driving goal of their efforts was to construct a unified history of mathematics inspired by

[67] See the AIST2020 homepage at http://www.aict.info/index.php?csc = 2020. Although technically held under the umbrella of the Azerbaijan Joint Chapter of the American professional society IEEE (Institute of Electrical and Electronics Engineers), the locations of the AIST conferences since 2009—including Azerbaijan, Uzbekistan, Georgia, Kazakhstan, Russia, and Ukraine—reveal the Soviet heritage of their constituency.

[68] See AIST2020, "Scientific Pilgrimage to al-Khwarizmi's Birthplace," http://www.aict.info/index.php?csc = 2020&mod = scientific-pilgrimage.

dialectical materialism, a goal that eventually embroiled them in arguments about the algorithmic character of mathematics in the East. For the Moscow-based historians of mathematics, Arabic-language mathematics from Central Asia were first and foremost ideas captured in medieval texts but inherently portable. Computer scientists in search of the origins for their discipline drew on this portability by appropriating the existing historical narratives as building elements in the representation of al-Khwarizmi as a founding father figure and the Khwarezm region as the cradle of the algorithm. Local, republican, and all-Union commemorative practices benefited from this international validation by the experts, further enhanced by UNESCO's involvement in the 1983 festivities. The 2020 commemorative efforts illustrate the ongoing mobilization of the transformative symbolism held by al-Khwarizmi, this time in order to signal belonging among the producers, not the consumers, of an algorithmic civilization.

If culture is passed down along with history objects and memory subjects, where does that leave the historians of algorithmic cultures? To question the who, where, and how of the commemorated Soviet past of the algorithm is not so much an exercise in correcting the errors of myth making but an opportunity for probing our methodological limits. For instance, a recent overview of the concept of the algorithm in European mathematics offers brilliant observations from a longue durée perspective but oversimplifies both Knuth's and Markov's intellectual legacies, precluding the recognition of interactions with alternative algorithmic cultures.[69] The significance of al-Khwarizmi's anniversary studied in this chapter could not be explained solely as a geographical extension within the established notions of commemoration, developed for the studies of Western science, and supports the case for a greater methodological engagement with area studies—in particular post-Soviet spaces—and with the Marxist and socialist intellectual legacy more broadly.

Last but not the least, the circulation of ideas about algorithms helps us acknowledge a fuller and a more open genealogy of the history of science as a field shaped by interdisciplinary and international interactions beyond Anglo-American centers. In a recent essay, "All Roads Come from China," Chemla theorizes her insights on breaking the association between the values of generality and abstraction in mathematics.[70] Shedding light on the sources of Chemla's methodology and its development, the essay establishes the relevance of the works produced by Yushkevich's students to her close reading techniques of ancient Chinese manuscripts. The French historian explains how this methodology that she devised helped to reveal formal cognitive work on lists of operations and to change the misconception presenting Eastern mathematical manuscripts composed of seemingly concrete problems and algorithms solving them as practice-oriented and theoretically poor. Moreover, Chemla identifies how, upon the first discovery of Knuth's work in conversation with the Chinese topologist and historian Wu Wenjun in 1981, the computer scientist's attention to mathematical operations of assignment of variables, iteration, and conditionals emboldened her reinterpretation of ancient Chinese sources and came to infuse her research program up to today.[71] In

[69] Mingyi Yu, "The Algorithm Concept, 1684–1958," *Critical Inquiry* 47, no. 3 (2021): 592–609.
[70] Karine Chemla, "All Roads Come from China—For a Theoretical Approach to the History of Mathematics," *European Mathematical Society Magazine* 119 (2021): 23–30.
[71] Karine Chemla, "From Reading Rules to Reading Algorithms: Textual Anachronisms in the History of Mathematics and Their Effects on Interpretation," in *Anachronisms in the History of Mathematics: Essays on the Historical Interpretation of Mathematical Texts*, ed. Niccolò Guicciardini (Cambridge: Cambridge Univ. Press, 2021), 42.

other words, this chapter's story of how the history of the algorithm was claimed by Marxist historians of mathematics and by computer scientists percolates historians' present-day intellectual agenda.

Unraveling this last thread in the algorithm's origin story exposes my own intellectual debt to the seminars on the historiography of mathematics organized by Chemla, who also shared her recollections about visiting Moscow historians and instigated my inquiry into the context of Yushkevich's interest in algorithmic mathematics. My acknowledgment of the intellectual genealogy of my attempt at combining the studies of commemorative practices and the history of science studies leaves this chapter with a (self-)reflection on historical craft that is purposefully open-ended: to historicize the global modalities of algorithmic cultures takes on the historian's work of suspending the assumptions of universality.[72]

[72] SAW (Mathematical Sciences in the Ancient World), "Writing Histories of Ancient Mathematics: Reflecting on Past Practices and Opening the Future, 18th–21st Centuries," conference, Paris, October 24–28, 2016, https://sawerc.hypotheses.org/conferences/conference-octobre-2016.