at the Institute of Precision Mechanics and Computing Technology emphasized English-to-Russian direct translation. Panov even visited IBM headquarters in New York to observe the 701 in action, and commissioned a fairly detailed account by two computer scientists of what was known about the experiment for the major journal of Soviet linguistics.[2] He and his colleagues were even permitted to publish a high-profile review of their work in *Pravda*, the Party's central newspaper.[3]

From these beginnings, it only grew. The first Soviet publications on MT began to appear in late 1955. Just three years later, a conference in Moscow drew 340 representatives from 79 different institutions (21 of these were ensconced within the cavernous domain of the Academy of Sciences) to hear 70 presentations. By 1964, Yehoshua Bar-Hillel—who had been the very first full-time researcher on MT in the world in 1952—declared the Soviet Union "the leading country of MT."[4] Given the relatively limited contact between the Soviet and Western groups in the early years, it is unsurprising that programming strategies began to diverge. The most significant difference was to separate the program "into two fundamental parts—analysis and synthesis,"* that is, parsing the sentence first and then demanding a different protocol to inflect the root stems and endings.[5] The Soviets also pioneered the development of "interlingua" programs, which rendered source material into an abstract code which could then be transformed into several other languages by independent protocols, a strategy indebted both to programming and linguistic traditions as well as the Soviets' need for multilateral translations due to the multilingual nature of their country.[6]

The Soviet Union erected this massive MT establishment out of fear of the Americans; the United States returned the compliment. News of Soviet interest in machine translation jumpstarted Léon Dostert's abortive efforts to obtain a large grant to develop the limited Georgetown-IBM experiment. Dostert noted with great satisfaction (and even greater understatement) in 1957 that publicity of Soviet experiments on their BESM machine "was not unrelated to a renewal of interest and support for work in MT in the United States. In June of 1956 Georgetown University received a substantial grant from the National Science Foundation [NSF] to undertake intensive research for the translation of Russian scientific materials into English. This grant has been renewed for a second year of continued research."[7] The push-me-pull-you character of the "MT race" between American and Soviet programs was an

*"на две основные части—анализ и синтез."

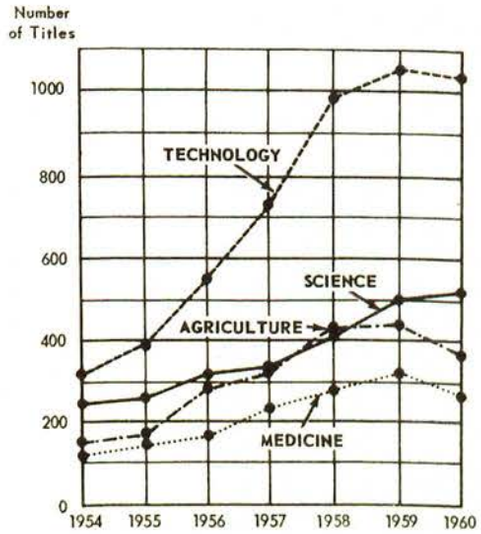

FIGURE 9.1. Number of different journal titles in science and technology produced in the Soviet Union, from 1954 to 1960. Both the sheer quantity and the massive growth were characteristic of Soviet scientific production during the Cold War. Boris I. Gorokhoff, *Providing U.S. Scientists with Soviet Scientific Information*, rev. ed. (Washington, DC: Publications Office of the National Science Foundation, 1962), 4.

open secret among the global community of researchers. Anthony Oettinger, who led Harvard University's program, later described it as "a kind of amiable conspiracy to extract money from their respective governments, playing each other off with various 'experiments' and 'demonstrations' that sometimes bordered on fraud."[8] These accusations evoke some of the negative evaluations of the original Dostert experiment, and that 1954 demonstration would continue to be a touchstone—positive and negative—for the developments that followed.

The Americans still perceived themselves in the throes of a translation crisis, a necessary by-product of the scientific and technological competition that gripped the superpowers. MT was only one of the solutions proposed to deal with the perpetual avalanche of Soviet publications in the natural sciences. The number of journals alone expanded almost exponentially, and each of these cried out for American readers to figure out what "Ivan" was up to. (See Figure 9.1.) Exhortation to learn Russian thus continued as a parallel strategy alongside MT. (And, ironically, one rather desperately needed by MT researchers themselves. One of the consequences of Soviet investment in this area was the pro-

duction of valuable Russian-language studies that many of the American researchers complained about not being able to read![9])

The language barrier began to assume a different character in the mid-1950s. Those scientists and linguists who propounded the notion of "scientific Russian" viewed it as the province of individual decisions: to learn Russian, to research on machines, to pen editorials that the sky was falling. In the latter half of the decade, the language crisis began to be perceived as a national problem that was amenable to solution by the state. This was less surprising in the Soviet Union, where most scientific problems were viewed this way, but in the United States it represented something of a sea change that would permanently alter the terrain of debate. Thus, around 1955, not only did the state charge into MT on both sides of the Iron Curtain, but in the United States even the fledgling enterprise of cover-to-cover translation of Soviet journals—which will occupy the bulk of this chapter—was transformed from an entrepreneur's gamble to the largest translation program in the history of science. In following this intertwined history of MT and cover-to-cover translation, we see that the "language barrier" comprised three distinct, though related, issues: language of publication, quantity of information published, and access to the material. MT focused on the first to the neglect of the others, an oversight that would be partly responsible for its catastrophic collapse by 1966.

The Great MT Gold Rush

The beginnings of the 1956–1966 boom in machine translation can be traced not so much to the Georgetown-IBM experiment as to its progenitor, Léon Dostert. Dostert, as we have seen, persuaded Thomas Watson of IBM to donate the dictaphone technology that made simultaneous translation a success at Nuremberg and at the United Nations, and then again to underwrite the enormous opportunity cost of time on the IBM 701 that made the 1954 experiment possible. But during the war, while working alongside the Office of Strategic Services, America's intelligence organization, he met his greatest patron: Allen Dulles. In 1956, after the Office of Naval Research and Army Intelligence had declined to fund MT, Dulles came through in a big way. Three years earlier, Dulles had become the head of the Central Intelligence Agency (CIA) in the new administration of President Dwight Eisenhower. Dulles wanted to know what the Soviets were doing, he had far too few

Russophone analysts, and "Léon" claimed he could make this happen through his machines.[10] Dulles was willing to pay.

Although not, at first, entirely openly. Dostert had pitched an apparently very modest goal to the NSF in 1956: "To focus research for the purpose of achieving, mechanically, as complete translation as possible from Russian into English in the field of chemistry, primarily organic." Basing themselves on texts from the Soviet *Journal of General Chemistry* (*Zhurnal obshchei khimii*), the most important chemical publication in the Soviet Union, Dostert's team of researchers "will aim at the presentation of *unedited* Russian texts at the input and strive to achieve *semantically accurate translation* in English at the output, although the output material may require stylistic editing if this is found to simplify the storage problem." He expanded his earlier plan, now proposing to hire seven linguists, eight linguistic research assistants, five Russian-to-English translator-lexicographers, six bilingual clerical assistants, a bilingual secretary, and an administrative secretary, for a budget of $103,850 (over $900,000 in 2014 dollars).[11] Dostert made sure the award received wide publicity, both in Georgetown publications and in Washington newspapers.[12] What the reports did not say was that a good deal of this money was CIA cash, simply funneled through the NSF. The NSF numbers from 1956 through 1958 were $100,000, $125,000, and then $186,000—$305,000 of which was from the CIA—with subsequent direct CIA infusions without the NSF middleman totaling $1,314,869 (over $9.7 million in 2014 dollars). This was by far the largest award of funds for MT to any institution in the United States, and by 1962 even Georgetown's publicity team openly acknowledged CIA sponsorship.[13] When questioned by a Congressional committee about these sums in 1960, both the anonymous CIA witness (almost certainly Paul Howerton, the one-time MT skeptic who became CIA case officer for the project) and Dostert defended these numbers by laconically noting that the Soviet Union was even more heavily invested in MT than the Americans.[14]

Dostert built up an MT program at Georgetown commensurate with these sums, unheard-of for almost any project outside of nuclear physics or public health.[15] He stressed organic chemistry, because, as this 1959 internal report made clear, that science lent itself to MT:

> The theoretical necessity for such a routine lies in the fact that the number of organic compounds is in theory infinite; and in practice

> it is enormous. Therefore it seems wasteful to burden the main dictionary with literally hundreds of thousands of very long items. Secondly, compounds can be and are created in the laboratory for the purpose of studying them. Names are created for them according to established rules, names which can be translated by this type of routine. But after laboratory testing the particular compound may never be made again, and its name never appears in the literature again. Thirdly, the freedom with which carbon can combine with itself over and over and with other elements means that a dictionary which is relatively complete in other areas of the chemical language can never hope to have all the organic compounds in it. Therefore the need for a machine technique to analyze chemical terms.[16]

The corpus of words garnered from the analysis of only a few years of the *Journal of General Chemistry* was enormous (24,000 words by 1957).[17]

The linguistic results were promising. For example, the rules for adding definite articles to plural nouns in chemistry texts applied about 80% of the time—which seemed pretty good—and the rule worked "even for general texts, although to a lesser degree."[18] Coding continued apace. By the end of the decade, 85,000 more terms in organic chemistry had been keypunched, composed of about 8,000 distinct words, which reduced to 3,200 entries (notice the compression characteristic of scientific language). Labor costs became a concern, and Dostert rented commercial space in Frankfurt, Germany, in 1960, recruiting 200 keypunch operators for $80/month, a quarter of the American wage.[19] Georgetown won the coveted contract to translate Russian atomic-energy documents into English for both the Atomic Energy Commission at Oak Ridge, Tennessee, and for EURATOM in Ispra, northern Italy.[20]

Not surprisingly, Dostert's success sparked resentment. When A. D. Booth and William Locke published the proceedings of the 1952 MIT conference in 1955, Dostert's was the only essay to receive a cautionary editorial footnote: "Its inclusion in this book reflects the editors' desire to cover all aspects of the application of machines to translation and should not be taken as indicating their acceptance of all the author's views."[21] Dostert's lack of hard-core linguistic publications was probably the heart of the worry, but the showmanship contributed. Anthony Oettinger would later recollect Dostert as "a great conversationalist[...], but as a researcher I was unsure about him, whether he was just a figurehead or whether he was a bit of a fraud—the Georgetown MT demonstrations seemed always to be contrived; they made impressive

publicity for the sponsors, but they soured the atmosphere by raising expectations that nobody could possibly fulfil."[22] Booth, for example, gleefully dismissed Dostert as "one of the less esteemed members of the American MT community."[23] MT colleague Winifred Lehmann was overheard describing him as "a wart on the field of linguistics."[24]

Yet Dostert's rising tide lifted all boats: the more he stumped for MT, the more grant money flowed to everyone. By 1960, five separate governmental agencies—NSF, CIA, the Army, Navy, and Air Force—were all funding mechanical translation at a steadily growing rate. The National Defense Education Act, passed on 2 September 1958 as a response to Sputnik, specifically indicated that the NSF and other groups "undertake programs to develop new or improved methods, including mechanized systems for making scientific information available."[25] That same year, the Army and the Navy joined in the funding boom.

Meanwhile Victor Yngve and William Locke at MIT devoted themselves to building a professional community of MT researchers. In 1954, the year of the Georgetown-IBM experiment, they established *MT: Machine Translation*, the first journal exclusively devoted to this topic. The early issues were composed on an electric typewriter in Locke's office, and eventually the journal moved to a commercial compositor. *MT* could only sustain that change with page charges, which granting agencies were initially happy to subsidize. In June 1962, a professional society for MT was founded, at which point the irregular *MT* had already published 52 articles and 187 abstracts in its total of 532 pages. It moved to Chicago with Yngve, and then to University of Chicago Press, but the costs proved too great and the journal foundered in 1970.[26] The story of *MT* is the story of MT in miniature: high hopes in 1954, massive grants, and then, around 1965, a precipitous collapse.

But catastrophe was the furthest thing from the minds of the dozens, and then hundreds, of linguists, programmers, statisticians, and engineers who flocked to machine translation. MT began to reshape linguistics in turn. Some have linked MT to the revival of structuralism—an approach developed decades earlier based upon the teachings of Ferdinand de Saussure (brother of the editor of the Esperantist *Internacia Scienca Revuo*). The tremendous postwar rise of structuralist analysis of language is often identified with the immensely influential work of Noam Chomsky in the late 1950s. Yet the receptive audience for that work was partially conditioned by the flurry of MT publications. In 1963, Dostert noted that the "development of structuralism in contemporary linguistics is at the basis of the concept of machine

translation, since, without structuration procedures, the idea of sign-substitutions or automatic transfer of linguistic data would hardly be conceivable," and even his arch-rival, A. D. Booth, considered it axiomatic to assume "that structural linguistics as a science has already progressed to a state in which it is possible to devise adequate rules of procedure for translation from one language to another in terms which can be understood by a computing machine."[27] Structuralism's resurgence in Western thought—in linguistics, in philosophy, in anthropology—fit perfectly into the climate fueled by the intensity and raw financial support that flowed into MT.

This was especially visible across the geopolitical divide. Stalin's 1950 intervention in linguistics had the consequence of firmly establishing historical-comparative linguistics within the Soviet Union, as we saw in the previous chapter. In the Soviet context, that attention to the diachronic evolution and transformation of languages effectively countered structuralism's emphasis on synchronic analysis of linguistic structures. A year after Stalin's death, Liapunov jumpstarted Soviet MT. Given the symbiotic relationship between algorithmic machine-translation processes and structuralist analyses of language, it is no exaggeration to say that Soviet research at this intersection rescued Soviet structuralism, morphing Soviet linguistics into perhaps the most structuralist of any national community in the world.[28]

Abstracting the World

I have described the story of the Russian-English language barrier as principally an American story, one in which scientists and policy makers in the United States confronted a challenge posed by Soviet technical publishing. This lopsided emphasis has something to do with the sources: the Americans simply wrote more about this problem *as a* problem. Yet despite their panic, Americans could afford to be nonchalant about the language barrier. After all, by the 1950s over 50% of world publication in such sciences as chemistry was appearing in English. The Soviets could not just ignore that work, and so their approach to the language barrier tended to be more holistic than that of the Americans, who sometimes casually dismissed Soviet work as substandard. For the Soviets it was not just about *language*, but also about *quantity* of information and *access* to it. The Soviet solution to the latter two problems would in turn challenge American attitudes to the organization and distribution of scientific information.

Consider a seemingly simple problem: how did you learn about scientific findings happening outside your laboratory, whether down the street or across the ocean? (This was, recall, in the days before there was an Internet, let alone online databases or search engines.) One approach was to select the main journals in your field and then regularly thumb through each issue, studying the table of contents, reading many of the abstracts, and focusing on the relevant articles. Of course, if an article cited a significant paper in a journal outside the regular set, that would lead to another article, and crawling down the citation chain could enrich your research. Yet this approach was maddeningly incomplete, essentially guaranteeing missing important articles in your subfield unless some other scientist happened to have a broader bibliographic base and then published about it. There had to be a better way.

There was: the abstract journal. The most comprehensive of these in English was the American *Chemical Abstracts* (which surpassed the German *Chemisches Zentralblatt* in coverage by the interwar period). The editors of *Chemical Abstracts* surveyed a very broad set of journals, in several languages, and then paid a per-abstract fee to an army of chemists to summarize articles from the journals to which they were assigned. You used it like a massive index. Yet there were three difficulties with this system: size, speed, and scope. *Chemical Abstracts* was huge. By the late 1950s, each annual issue produced 100,000 abstracts spread across 10,000 pages of close printing; even the index was 5,000 pages long.[29] Physically handling these volumes, let alone extracting useful information from them, was a chore. Time was a related issue: the more articles there were, and the more journals needed to be covered, the longer it took to abstract the current year. And then there was scope: *Chemical Abstracts* was confined to chemistry (albeit broadly construed). Could the abstract journal be fixed?

By the late 1950s, it seemed to scientists on both sides of the Iron Curtain that the Soviets had done it. Russians had been abstracting for a long time, but partially and incompletely. The first Russian abstract journal, the *Guide of Discoveries in Physics, Chemistry, Natural History and Technology* (*Ukazatel' otkrytii po fizike, khimii, estestvennoi istorii i tekhnologii*) appeared from 1824 to 1831, and despite its title was hardly comprehensive, even for its limited lifespan. Individual subfields developed their own abstract journals in Russia: there was one for medicine from 1874 to 1914 and one in railroad engineering from 1883 to 1916, but the Great War and the Russian Revolution ended those. Very little was done to systematize scientific information during the first decade

of Soviet power. On 9 January 1928, the state established a Commission for the Compilation and Publication of Indexes of Scientific Literature, designed to abstract everything published in the Soviet Union, but it soon bogged down under the weight of material and Stalinist upheaval. The 1930s saw a return to abstract journals in several fields, but once again war's advent ended several projects. Medical abstracts returned in 1948, but the other sciences were left uncataloged.[30]

Then, on 19 June 1952, the Soviet Academy of Sciences established an institute specifically to collate and publish information on scientific publications from around the world, responsibility for which was soon shared with the State Committee of the Council of Ministers of the USSR on New Technology (Gostekhnika). The new institute was called the All-Union Institute of Scientific and Technical Information, or VINITI in its Russian acronym. At first, VINITI's central product was *Referativnyi Zhurnal* (*Abstract Journal*)—from which Liapunov had learned about the Georgetown-IBM experiment—which assiduously sifted through the international literature. It quickly eclipsed its Western rivals. Beginning in 1956 VINITI also produced *Ekspress-Informatsiia*, translations of crucial Western articles and pamphlets into Russian, and in 1957 issued a monograph series, *Advances in Science and Technology*. The Institute also put out photo-offset copies of roughly 300 Western journals (such as the American behemoth *Physical Review*), identical to the original except for noticeably poorer paper quality. On 29 November 1966, VINITI assumed control of all the science-information services of the Union republics as well, becoming "the largest scientific information centre in the world," according to a British delegation. At the end of its first decade, VINITI's permanent staff reached 2,500, not including those working at its publishing house, or the 22,000 specialists who produced the over 700,000 abstracts it printed each year.[31]

VINITI was intended to be a solution to all three aspects of the language barrier. By centralizing information and reprinting foreign journals, it could more easily tame the exponentially increasing quantity of global scientific information as well as granting access to foreign scientific periodicals within the Soviet Union. As for the language aspect of the barrier, *Referativnyi Zhurnal* bypassed it. Each abstract in the sixteen subsidiary abstract journals (divided by science, with chemistry being the largest) had the same form: article title in Russian, author's name in Russian transcription, title in the original language, author's name in the original, name of journal, year, volume, issue, page,

the name of the language, the abstract in Russian, and the abstractor's initials. All the foreign language text was reproduced in the original typography, whether the writing system was Cyrillic, Latin, Arabic, Devanagari, or Chinese.[32] Soviet scientists were expected to command several foreign languages, and many in fact did, yet VINITI continued to translate 85% of the world's scientific tables of contents into Cyrillic so that everything could appear in standardized form.[33]

As one might expect, it was difficult to keep such an enterprise going indefinitely. By the late 1970s, *Referativnyi Zhurnal* lost its edge while VINITI became increasingly strapped for resources and personnel, stabilizing its coverage at a whopping 1.3 million abstracts a year while the scientific literature mushroomed ever larger.[34] But in the 1950s and into the 1960s, VINITI was the envy of American science planners, ostensibly demonstrating why the Soviet Union had been able to assume the lead in the space race, as well as eclipsing the United States in the training of scientists and engineers. The tremendous American investment in machine translation has to be understood against the backdrop of the total picture of Soviet science-information efforts as obsessively tracked by Western observers. And just as the Soviets were pouring money into automated translation, the Americans believed they needed to do something else to surpass (or at least keep up with) the Soviets. Complete centralization was unlikely in the American political climate, but even a partial intervention to bridge the language gap would be welcome.

Retail, Wholesale, and Welfare Translation

According to the science press in the 1950s, MT played the starring role in the drama of Cold War scientific languages. As the decade progressed, however, a bit player began to assume an ever greater share of the lines: direct human translation of Russian articles into English. While MT focuses on the linguistic aspect of the language barrier, human translation adds access to sources by providing readers with a version of the article they want in a language they can read. (Both approaches are, however, bedeviled by quantity: the more material there is, the more there is to translate, and the harder it is to keep up.) The idea behind training Americans to read scientific Russian was, of course, to turn each scientist into his own translator. Translation journals were supposed to be a stopgap.

If you wanted to read a short story by Anton Chekhov but did not know Russian, you would look for a translation into a language you

did know. Therefore it is not surprising that from a very early stage the notion of translating selected articles was seen as a remedy for the Cold War translation crisis. Starting in the late 1930s, a consortium of American petroleum companies employed one of the leading bibliographers of Soviet science, J. G. Tolpin, to edit and privately circulate translated tables of contents, abstracts, and selected Soviet articles on hydrocarbon and petroleum chemistry, a venture that lasted for eight years.[35] The shared interests of the consumers drove the choice of what to translate, and the deep pockets of the industry bankrolled the staggering costs.[36]

For the federal government, the selection problem was more fraught. After World War II, it outsourced the editorial selection of translations to those presumably in the know. For example, the American Mathematical Society in 1948 initiated a program (funded by the Office of Naval Research) to translate the highlights of recent Soviet mathematics, and the newly created Brookhaven National Laboratory on Long Island began to translate the tables of contents of important periodicals but soon found themselves swamped by even this limited quantity of material.[37] To pool privately commissioned translations, the NSF funded a Translations Center at the Library of Congress (as well as a selective article-translation program for atomic energy at Columbia University), building on the Translation Index developed by the Special Libraries Association (SLA) in New York City. In 1953, the SLA Translation Pool moved to the John Crerar Library in Chicago, and in 1956 assumed the duties of the Library of Congress in its entirety, issuing monthly catalogs of the translations deposited with them.[38] The United Kingdom's Department of Scientific and Industrial Research experimented with a hybrid of translation pool and translating service: if two or more researchers independently requested a translation of an article, the state would pay for it and deposit it for general access.[39] These approaches suffered from two intrinsic faults: they were unsystematic, the selections being made arbitrarily at the whim of the editors; and they were untimely, since by the time the translation was deposited and cataloged, others might have already commissioned translations, or the information might simply have turned stale.

Earl Maxwell Coleman, who by his own admission had "no translation skills whatsoever," stumbled into this ramshackle world of technical translation by accident, and founded a publishing operation called Consultants Bureau, Inc., with his wife, Frances, (and the measly capital of $100) in 1946. That year, Coleman learned of a trove of twenty-one tons of captured German technical documentation, and he sensed

that someone could make money translating this material into English. Coleman approached the American Petroleum Institute, which had 100 microfilms of German-language technical reports at 1,000 pages per reel, and he made them an offer based on an unheard-of price scheme: $2 per thousand words instead of the industry standard of $12 (Coleman paid his men $10), but with multiple orders the price would drop gradually to a floor of 50 cents per thousand. That is, by pro-rating the translations he gave himself a guaranteed profit only if enough copies were ordered. Coleman kept losing money under this arrangement, while his translator, he claimed, flourished. Then Coleman had his second major insight: "I was paying him at a freelance rate even though I was keeping his lance at full tilt. It was as though I was paying him at a *rate* of $1,000 a week in a world of $50 a week salaries." Coleman ran back to the office and slashed the pay: from $10 to $4—starvation wages for a freelancer. "He ranted and raved and swore that he'd quit. He never did. Where else could he get as *much* work?—the *key*." By turning translation into assembly-line labor, Coleman changed the economics of the profession. He hired more translators, standardizing the job description in 1947 according to rules he maintained until the end of his career:

1) To work for me you had to have English as a mother tongue.
2) You had to have command of the target [sic] language because a) you'd studied it, or b) it was spoken fluently in your family.
3) If you were translating chemistry you had to *be* a chemist, or at a minimum have an advanced degree in chemistry.[. . .]
4) You had to be willing to work for me at $4 a thousand despite the impressiveness of the above demands. Implicit in the notion of so low a rate of pay was the following: You had to be able to translate *fast* or you wouldn't make enough money to keep you interested.[40]

In 1949, the same year Warren Weaver penned his memorandum on MT, Coleman revolutionized scientific publishing. He had developed a new industry but had no market. The difficulty was twofold: he focused on German, and there just was not enough demand; and he produced discrete articles. He decided to change both premises: "*Suppose*, I conjectured, you translated a whole Russian journal."[41] From the Consultants Bureau offices at 153 West 33rd Street in New York City, Coleman decided to translate the entire run of the *Zhurnal obshchei khimii*

(the same journal Dmitrii Mendeleev had published in almost a century earlier, albeit under a different name), as *Journal of General Chemistry of the USSR*. Translations of the first issue of the 1949 volume appeared in November 1949, eleven months late, to a total list of thirteen subscribers. Coleman borrowed money to keep his business afloat; within five years he produced five journals and within seven offered twelve entirely in-house. Coleman had become one of the most powerful individuals in scientific publishing.[42]

Coleman modeled Consultants Bureau on a factory template. First, the Russian originals would arrive by air mail and translators were invited to select specific pieces from the tables of contents. The editor then distributed the work, ensuring no piece was left out, getting translations back six weeks later. Those were edited for style and referred back to the translators (and, when he later subcontracted for learned societies, to boards there) for queries, then typeset, and hit the shelves six months after they arrived.[43] With this mode of production on a vastly larger scale, Coleman reduced the expense to 18 cents per thousand words—that is, under 2% of his 1946 expense (before taking inflation into account).[44] Who were these shockingly underpaid translators? A 1970 study of Coleman's stable found that most had PhDs and translated in their spare time, but there were full-time translators who had been there from the very beginning. This group turned out more than 34,000 pages of English from Russian originals a year.[45]

It wasn't pretty. The volumes initially came out on 8.5x11 sheets of paper—rather larger than the close-printed original—and were little more than bound mimeographed typescripts. The pagination did not match the Soviet originals, although starting in the "September 1949" issue (which appeared sometime in 1950) the table of contents listed both sets of page numbers. Images were crudely mimeographed, with all the annotations in the original Russian, and appended to the end of the articles rather than printed in-line as they came from the Soviet Union. By the second year the translated *Journal* included indices for author, subject, and organic chemical empirical formula. It also wasn't cheap. Coleman charged $7.50 for an individual article, $12 for an issue, and $95 for the whole year (almost $940 in 2014 dollars). Consultants Bureau took "cover-to-cover" seriously: there was no selection of the articles, and the idiosyncrasies of the Soviet original (lavish attention to the periodic table, nationalist priority claims, obituaries, historical pieces) were reproduced without comment.

The real question had to be: was it any good *as translation*? All too few American chemists could follow the Russian originals, so this was the best they had—but would an American chemist get *accurate* translations from Coleman's product? Consider a spot analysis on a randomly selected article by G. I. Braz on the reactions of ethylene sulfide with amines, taken from the third year of publication (1952). Early in the translation, one comes across this sentence:

> As we might expect, ethylene sulfide behaves similarly with diethylamine. When freshly distilled ethylene sulfide is added at room temperature to a solution of diethylamine in methanol, a white precipitate of polymeric compounds containing no nitrogen begins to settle out within a few minutes, the precipitation being complete within a few hours.[46]

Here is my rather literal rendition of the original Russian:

> As one would expect, ethylene sulfide behaves analogously also in relation to diethylamine. If one were to add at room temperature freshly distilled ethylene sulfide to a solution of diethylamine in methanol, then already in several minutes there begins the separation of a white precipitate of polymeric compounds which do not contain nitrogen, which ends in several hours.*[47]

Hardly any cause to complain. Toward the middle of the article, however, in a description of its core experimental procedure, I came across the following: "Fractionation of such a solution in a current of nitrogen after it had stood for 5 days at room temperature produced a yield of 60% of β-phenylaminoethanethiol."[48] Here is what the Russian actually says, in my translation: "Letting such a solution stand at room temperature for five days after fractionation in a stream of nitrogen produced β-phenylaminoethylmercaptan with a yield of 60%."†[49] The chemical product is listed differently. This is in fact the same compound, but the

*"Как и следовало ожидать, аналогично ведет себя этиленсульфид и по отношению к диэтиламину. Если к раствору диэтиламина в метаноле прибавить при комнатной температуре свежеперегнанный этиленсульфид, то уже через несколько минут начинается выделение белого осадка не содержащих азота полимерных соединений, заканчивающееся через несколько часов."

†"При стоянии такого раствора при комнатной температуре в течение 5 суток после фракционированной перегонки в токе азота β-фениламиноэтилмеркаптан получается с выходом 60%."

translator was inconsistent throughout the article about how he represented it, sometimes using the modernized name, sometimes an older nomenclature. It could have been a typesetter's error, or the product of rushed translation—either way, to a reader, this article would seem to be at best confused. The problem, as contemporaries indicated, was ineradicable in precisely this area: "Organic nomenclature problems arise from faulty translations.[. . .] This type of error is extremely difficult to catch in editing."[50] Yet what choice did the reader have? He or she could not check the original Russian. Cover-to-cover was all there was.

And soon, it was everywhere. Extant scholarly accounts of the history of cover-to-cover translation emphasize the massive translation initiative of the American Institute of Physics (AIP), supported by the NSF.[51] In 1955, the AIP sent a survey to 300 physicists about their views on providing either complete or selected translations, and 269 replied, with results that "(a) an overwhelming majority favor establishment of a Russian-to-English translation service, (b) appreciably more than half believe complete translations of Soviet journals would be preferable to translation of selected articles, and (c) about 90% are of the opinion that they or their organization would subscribe to such a journal."[52] According to the survey, 79.8% supported cover-to-cover translation "[b]ecause of the technical value of the research now in progress in the USSR," and 72.3% added a caution about "the national danger of underestimating the strength of the USSR, particularly as far as scientific advances are concerned."[53]

While Coleman created the industry almost by accident through calculating profit margins, the AIP debated the rationality of the venture from every angle before committing resources to it. In 1954 Elmer Hutchisson, later the director of the AIP and the man behind the 1955 survey, offered a laundry list of reasons why cover-to-cover was superior to selected translations:

> First, the administration and mechanics of a project in which selections are made is much more complex than one in which journals are translated completely in a regular manner. Second, in many cases it would be necessary to translate abstracts, at least, so that the judges would be able to determine which articles should be translated and which should not. Third, any attempt to make a selection will undoubtedly cause a delay. One would hope that after this process gets established and air-mailed page proofs are coming regularly, the English edition would be available shortly after the Russian edition. Further, because of the confidence that everything would be translated, which is available in a given journal, the appeal of the translated edition would be far greater and a more ready market would be found among libraries and industrial organizations.[54]

The reasoning made sense to the NSF, and they underwrote the cost of the first volumes, which helped keep the subscription price down. The procedures instituted by the AIP for their first journal—*Soviet Physics JETP*, a translation of *Zhurnal eksperimental'noi i teoreticheskoi fiziki*—edited by Robert Beyer, professor of physics at Brown University, were remarkably similar to the work flow developed at Consultants Bureau, and the experiences of the physicists who translated in the wee hours to earn diaper money are also reminiscent of Coleman's employees.[55]

As a matter of fact, the AIP was surprised to learn in 1954 that Consultants Bureau had been operating in the field—with five different journals already for sale, and without any government subsidy. "The venture presumably is successful," a liaison from the Library of Congress noted, "since it has been in operation for several years."[56] With NSF support, the economics were even more favorable than they had been for Coleman. A typical Soviet journal contained 500 words per page; a science journal, because of tables, images, and formulas, came in at roughly 300. With a volume comprising 1,000 pages (a reasonable estimate in 1955, a shocking undercount by decade's end), that meant 300,000 words to translate a year. This would cost $6,000–$9,000 for a single organization at industry rates, but with NSF support the production cost was reduced to 2.5 cents a page. That meant with 150–200 subscribers, you could cover the expense of translation; with 600 subscribers, you covered production; and with over 750, you would be turning a profit and could subsidize a new journal.[57] By 1956 *Soviet Physics JETP* had grown to 700 annual subscribers, with 2,600 pages of translated material distributed for the cost of translating 10–12 pages—a real bargain. The NSF promptly agreed to support three new journals: *Journal of Technical Physics,* the physics section of the *Proceedings of the Academy of Sciences of the U.S.S.R. (Doklady)*, and the *Journal of Acoustics*.[58] The pump was now primed, and cover-to-cover ventures proliferated. As each title gained subscribers, the importance of the subsidy diminished and could be moved to start a new journal. The cycle repeated itself, and private firms started to join the gravy train. By 1958, there were 54 cover-to-cover translations of Soviet journals, and 85 in 1961.[59] (See figure 9.2.) Consider what was happening here: each

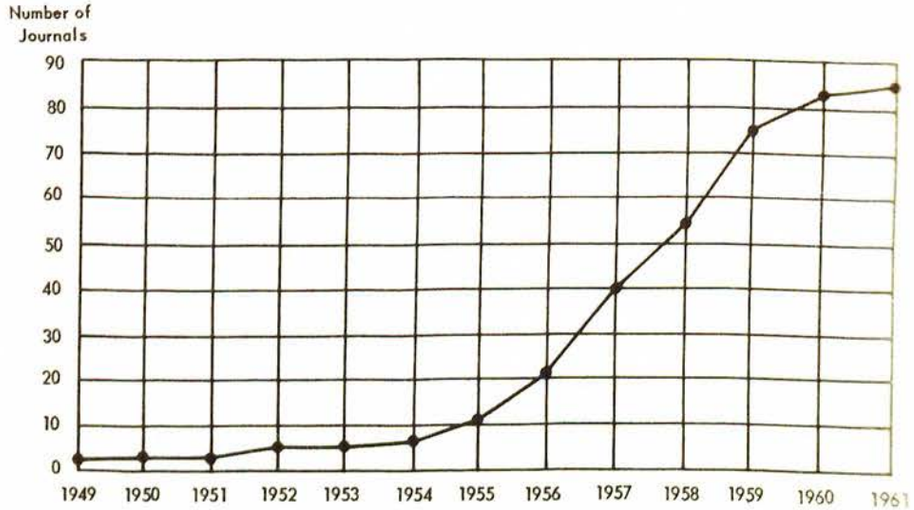

FIGURE 9.2. Number of English cover-to-cover translation journals from Russian, from the inception in 1949 (*Journal of General Chemistry of the USSR*) to 1961. Notice the rise after the AIP/NSF collaboration began in 1955. Boris I. Gorokhoff, *Providing U.S. Scientists with Soviet Scientific Information*, rev. ed. (Washington, DC: Publications Office of the National Science Foundation, 1962), 15.

month a hefty tome would arrive at an office in the United States, be ripped apart, distributed, translated, edited, stitched back together, and printed, all within six months—and this was done for dozens of journals, every month, for decades. It was the largest scientific translation project in the history of the world.

It was also, in the eyes of some, an administrative and bibliographic disaster. The complaints were legion, encompassing every aspect of the enterprise and expressed both behind closed doors at the AIP and openly in the pages of science journals. Did cover-to-cover violate copyright? (Since the Soviet Union did not yet adhere to international copyright conventions, this concern was dismissed.)[60] The leaders at the AIP were also very worried about explicitly propagandistic articles in Soviet science journals. Should those be translated alongside the regular science? Views ranged on both sides of the issue for years, but the AIP settled in the end for omitting such "non-scientific" pieces.[61] (This issue did not bother Coleman; *Journal of General Chemistry of the USSR* translated, without comment, a congratulatory message to Joseph Stalin on

his seventieth birthday.[62]) Lack of standardization bedeviled cover-to-cover enterprises, with at least fourteen different transliteration systems from Cyrillic, with different translators, editors, and journals rendering authors' names differently, frustrating indexing and abstracting.[63]

The two most significant problems were the delay and the expense. Time-lags were inevitable, given that one had to wait for the Soviet journal, translate it, and produce an entirely new issue. Robert Beyer noted in January 1957, after two years of experience, that his journal was "appearing 7 months behind official publication date."[64] Politics on both a micro and macro scale were partially responsible. In 1948, the Soviets temporarily held up all shipments of scientific journals to the United States because an ill-considered regulation required all foreign mail to be cleared through Foreign Minister Viacheslav Molotov's office, generating an incredible backlog. When journals arrived in America, on the other hand, the New York post office had been known to quarantine the material lest it contain dangerous propaganda.[65] Those hiccups were cleared (relatively) quickly, but they masked a deeper problem. The intrinsic delays in producing cover-to-cover journals and the vagaries of the Cold War meant that scientists who wanted their translations right away continued to commission their own, which generated wasteful duplication and further taxed the limited corps of technical translators.[66]

Cost was even more serious. *Soviet Physics JETP* contained 1,500 pages in 1955, which yielded a net price of $30 for an annual subscription (converting to an astonishingly low translation cost of 2 cents a page). By 1965, however, the Soviet original had bloated *threefold*, which meant the price had to skyrocket to $90 (not counting inflation) to break even, which in turn depressed demand.[67] And this was for the AIP's flagship translation journal, with the greatest subsidy and the greatest reader demand. For more boutique periodicals, like *Soviet Aeronautics*, the cost of the cover-to-cover translation reached 28 times the price of the Russian-language original, and the average circulation of the journals was 200–300, well below break-even.[68] Eugene Garfield, the information scientist who pioneered the *Science Citation Index* and transformed scientific bibliography, was scathing about the practice—and the government's intervention—in 1972, when cover-to-cover had taken over as America's chief strategy for following Soviet science:

> Since the government did not allow the demonstrated needs of international scientific communication to impact the information

> marketplace, the economic and other forces of natural selection were not allowed to operate. As a result, government fiat has produced a monster that continues to plague libraries, science administrators, and, in the final analysis, the taxpayers who feed the monster. Many research libraries feel forced to buy both Russian and English editions of leading Soviet journals, even though the latter generally appear six months to a year after the original. Those libraries which obtain only the translated version often find they are not used as often as expected. Bibliographically, the situation is a horror.[69]

In effect, in attempting to read Soviet science, the Americans had replicated the most inefficient features of the Soviet science system. Being journals, cover-to-cover fit into libraries' conventional purchasing patterns (unlike translation pools), yet produced bloated budgets and overcrowded libraries without helping anyone locate information, and so added to the glut.[70] The language barrier had been swapped for information overload, on a one-to-one basis. The journals were in English, but no one had time to read them.

Exit Machine

The woes of cover-to-cover translation began to impinge on the other hope for transcending the language barrier: machine translation. Recall that when Léon Dostert organized his program around a corpus of texts in organic chemistry, he selected the *Journal of General Chemistry of the USSR*, so that he could use this ready bilingual corpus to keypunch in terms and work out grammar algorithms. Cover-to-cover would work hand-in-glove with MT, obviating the need to develop translations from scratch. Or so he thought. Dostert quickly learned that the "English-language version was found to be inadequate for machine translation purposes and two persons were assigned the task of preparing a standardized translation which would be free of stylistic idiosyncrasies and as consistent as possible."[71] Precisely because the *Journal* was translated by teams of different people, syntactic and lexical correspondences were not standardized, which was what machines demanded.

Soon, dissidents emerged within the heart of the community, armed with trenchant critiques that threatened to topple the fundamental assumptions of the entire project. By far the most powerful assault came from none other than Yehoshua Bar-Hillel, the Israeli philosopher who had convened the first MT conference at MIT back in 1952. In 1958, Bar-Hillel undertook a tour of all the major Western MT institutes—with especial attention to Georgetown, for "[t]here exists no other group in the United States, or in England for that matter, which has been working on such a broad front"—finding an industry with between 200 and 250 people working full time with an annual outlay of roughly $3 million. Six years earlier, there had been the equivalent of about three full-time researchers with a total budget of $10,000, and the only individual working exclusively on MT had been himself. In 1960 he published a revised version of his working paper about this tour, incorporating his findings from Western accounts of Soviet research, and he came to the conclusion that "fully automatic, high-quality translation (FAHQT)," the stated goal of most research programs, was impossible, "not only in the near future but altogether." Language could not be reduced to algorithmic rules, because humans constantly imported context with serious semantic implications. His chief example, which soon became canonical, was the difference between "The box is in the pen" and "The pen is in the box." We intuitively know that the term "pen" in the first sentence probably is a place with animals, and in the latter might be a writing implement; in both instances, we apply our contextual knowledge of relative size—something a computer could not do. He did not spare scientific language: "Fully automatic, high quality translation is not a reasonable goal, not even for scientific texts."[72] To tell the truth, Bar-Hillel had said something similar as far back as 1953 ("Fully automatic high-accuracy translation seems out of the question in the near future.[. . .] Therefore, either the high accuracy or the complete automatic character of the translation process must be sacrificed"), and even in 1951 had insisted that "high-accuracy, fully automatic MT is not achievable in the foreseeable future."[73] But now, patrons were listening.

Hints of a coming storm emerged in May 1960, when Congress summoned Dostert for testimony in a series of hearings on MT. In September 1959, Dostert had resigned as director of the Institute of Languages and Linguistics so he could devote all of his time to machine translation. In short order, he had an operational system: Georgetown Automatic Translation (GAT). In 1964, Georgetown delivered GAT, designed for the IBM 7090 to translate Russian into English, to the US Atomic Energy Commission and to EURATOM. EURATOM kept using it until 1976, when it was replaced by SYSTRAN, while the Americans maintained GAT until at least 1979. The MT community

tended to be rather acerbic about the system; one later analyst complained that "[t]here was no true linguistic theory underlying the GAT design; and, given the state of the art in computer science, there was no underlying computational theory either."[74] GAT's output still required post-editing by a subject specialist, although not necessarily one with knowledge of Russian. Yet its end-users were happy about what they got: 92% of users at Oak Ridge and Ispra considered the results "good" or "acceptable," and 96% said they would recommend MT to a colleague.[75]

Nonetheless, Congress wanted to know what happened to the miracle machine. Dostert marched across town with his team in tow and dazzled the Congressional subcommittee with tales of progress, as well as another demonstration—a spot-translation of a random chemical text—which the system mostly passed (though it took the evaluator four times as long to read the translation as an equivalent English-language text).[76] Dostert had other aces in the hole: two of the Representatives examining him were Georgetown alumni, and one had been his own student.[77] (He always did work best through personal connections.) Dostert secured only a temporary reprieve. Three years later, in 1963, the CIA withdrew all funds from Georgetown's MT program, and that same year Dostert left Georgetown for his other alma mater, Occidental College in Los Angeles.[78] He continued to lobby for MT, however, and in 1963—perhaps implicitly responding to Bar-Hillel's critique—he opined: "We should accept the fact that 'perfect' translation is neither *humanly nor mechanically* achievable.[. . .] What then should we aim for?"[79]

An answer was forthcoming, but it was not what Dostert hoped for. In April 1964, Leland Haworth, director of the NSF, requested the National Academy of Sciences to assemble an Automatic Languages Processing Advisory Committee (ALPAC) "to advise the Department of Defense, the Central Intelligence Agency, and the National Science Foundation on research and development in the general field of mechanical translation of foreign languages." Chaired by John R. Pierce of Bell Laboratories and composed of leading specialists in computer science, linguistics, and even MT (Anthony Oettinger was a member), ALPAC searched through the various funded MT programs looking for progress and efficiency. It concluded that it would be more economical to have specialists invest the short amount of time to come up to speed in Russian. When that failed, commissioning specific translations was cost-effective, and America's stable of translators was more than adequate to the task. "There is no emergency in the field of translation," they insisted. "The problem is not to meet some nonexistent need through nonexistent machine translation."

The prime evidence for the "nonexistence" of MT was, ironically, the very success of the Georgetown-IBM experiment. After providing examples of three translations by different systems of a single Russian passage, all of which were execrable, the report observed that "[t]he reader will find it instructive to compare the samples above with the results obtained on simple, or selected, text 10 years earlier (the Georgetown IBM Experiment, January 7, 1954) in that the earlier samples are more readable than the later ones." The problem with the Georgetown sentences was that they were *too good*: "Early machine translations of simple or selected text, such as those given above, were as deceptively encouraging as 'machine translations' of general scientific text have been uniformly discouraging."[80] Notice the word "deceptively." Dostert's very showmanship had sown the seeds of the collapse.

And collapse it was; seven years after the report's publication in 1966, a survey of the field depicted a wasteland—two years later, the three remaining government-funded MT centers had closed shop.[81] In 1965, the Association of Machine Translation and Computational Linguistics took over the journal *MT*, adding *and Computational Linguistics* to its title; three years later, it removed "Machine Translation" from its own name, and closed the journal down in 1970.[82] The ripples spread across the Iron Curtain as well, as one of the leading researchers of MT in the Soviet Union recalled:

> The effect of the ALPAC report in 1966 was as great in the Soviet Union as in the United States. Many projects were not funded any more; machine translation went into decline. The authorities had seen the ALPAC documents and concluded that if the Americans did not think it worthwhile to support MT, if they did not think there was any hope of MT, then nor should we.[83]

The Soviets and the Americans had goaded each other to invest more in machine translation, and now they would suffer the drought equally. MT as a field would not really recover until the 1980s. Léon Dostert would not live to see it. He died suddenly on 1 September 1971, at a conference in Bucharest, Romania.

Covered

Meanwhile, Earl Coleman was having a very good decade. Consultants Bureau seemed to effortlessly toss off new journals. By 1956, it was easily the biggest producer of cover-to-cover publications in science. Meanwhile, Robert Beyer, the editor of *Soviet Physics JETP*, was overwhelmed with the rapidly expanding Soviet journal. He consulted with AIP director Elmer Hutchisson about subcontracting some of their own journals to Coleman's outfit.[84] Rumors abounded that the translators for Consultants Bureau were incensed at their low pay, but the AIP decided that a limited partnership might be worth doing. After all, reasoned Wallace Waterfall, "the Colemans will undoubtedly do the best possible job for us in order to enhance their own reputations."[85] The AIP farmed out three journals to Coleman, and soon the publisher had 45 full-time employees and translators in the United States, Canada, England, Puerto Rico, and India. In 1958, he became the first Western publisher to offer a royalty to the Soviets for the privilege of translating their science, thus gaining exclusive Western rights (and preempting British publishing mogul Robert Maxwell from horning in on his territory).[86]

The partnership between the professional society (and its state backers) and the private publishing firm was not always smooth. In 1965, Coleman accused Beyer "with vigor and irritation about AIP ruining the translation field—first by paying its translators too much, and second, by getting out too elegant a translation journal."[87] Eventually his feathers returned to their customary unruffled state, and translators continued to be impoverished by Coleman's logic of compensation. In 1966, the AIP abandoned their fledgling efforts at a Chinese cover-to-cover journal, reasoning that Coleman would probably pick it up, and by 1968 Coleman began producing *all* the AIP's journals.[88] By 1970, the renamed Plenum Publishing Corporation continued to tower over the competition. It produced 72 journals, comprising 75,000 pages of text a year—62 of these journals were independent, eight for the AIP, and others for the American Mathematical Society and the American Society of Civil Engineers. The nearest competitor was Faraday Press in New York City, with 29, followed by Scientific Information Consultants in London, with nine. Coleman controlled well over half of the cover-to-cover market.[89]

And that market was poised to take over the world, literally. One has to be careful when estimating the global reach of cover-to-cover translation, for certain features of the industry were peculiarly American. Of the 162 such journals—still only a tiny fraction of the estimated 2,600 to 4,000 Soviet scientific periodicals—published in 1968, some 85% were produced by the Americans. The rest but two were British (the exceptions were a Canadian journal on the Arctic, *Problems of the North*, and the lone non-English journal, the French *Prospection et protection du sous-sol*, on geology).[90] Through the NSF, the American state backed, at least in part, 45 separate ventures in 1960 alone.[91]

But despite the obviously American features of both MT and cover-to-cover translation—the mounds of Cold War money, the insistent focus on Soviet science, the overwhelming emphasis on English—the latter venture proved durable in large part because of factors outside the United States. In 1954, Frances Coleman explained that if the *Journal of General Chemistry of the USSR* had been forced to rely only on domestic markets, it would never have survived. "[B]ut then subscriptions and inquiries began to trickle in from Holland, France, India, Japan, and elsewhere. We realized that these translations would serve a purpose—and have a market—not only in English-speaking countries as we had envisaged, but also in any country where there were chemists who could not read Russian and could read English," she noted. "At the end of our first year more than half of our subscriptions were going to non-English speaking countries."[92] The same year as the Georgetown-IBM experiment, Consultants Bureau sent the journal to seventeen different countries, representing eleven different native languages. The AIP found the same: by 1965 one-third of subscriptions came from outside the United States.[93]

This was a consequential difference from MT. That project, however international, focused entirely on the *production* of texts. Cover-to-cover, as befit its roots in the private sector, was from the beginning worried about generating consumer demand for their product. MT's dependence on state support meant that when ALPAC gave the granting agencies an excuse to pull the plug, there was nothing to fall back on. Léon Dostert's dream of transcending Scientific Babel purely through linguistic means, without attention to the quantity of information or access, foundered. Meanwhile, translation journals spread abroad. If you were a scientist in Pakistan, or Italy, or Brazil, you had to follow both American and Soviet science. Instead of learning two languages, the Americans had made it possible to get by entirely on English, and so it became more and more prevalent as the default language of science—not instead of learning about what the Soviets were doing, but *as a means* of learning what the Soviets were doing.

Interestingly, such an outcome was foreshadowed in the foundational text of American science policy, Vannevar Bush's *Science: The Endless Frontier* (1945). Discussing translations of Russian into English, the text noted that "[s]ince such work would benefit not only science generally in the United States but would very likely promote the use of English in other countries, it seems proper to recommend that the United States Government consider methods by which the cost of such work could be met."[94] In the aftermath of the Second World War, a series of decisions about confronting the challenge posed by Soviet science began to overwhelmingly tip the balance toward a global monopoly of English as a language of science. Nowhere was this more visible than on the Cold War battleground between the Soviets and the Americans, the land whose language used to dominate scientific publications in seemingly every field: Germany.

CHAPTER 10

The Fe Curtain

> Auch zwischen Volks- und Sprachgenossen stehen Schranken, die eine volle Mitteilung und ein volles gegenseitiges Verstehen verhindern, Schranken der Bildung, der Erziehung, der Begabung, der Individualität.*
>
> HERMANN HESSE[1]

It was May 1945, and Germany was broken again. After the Peace of Westphalia ended the religious wars in 1648, the German-speaking principalities that made up the Holy Roman Empire were fragmented to create buffer states throughout the middle of the European continent, and ever since the arrow of history seemed to point toward greater and greater unification. First Prussia swallowed up smaller duchies and kingdoms to grow to a point where it could, by the 1860s, challenge the political focus of the German regions: Vienna, seat of the Habsburg Empire. And then in 1871 most of the German-speaking lands unified into the *Kaisserreich*, a new continental empire to compete with Austria-Hungary, inducing consternation in the French and British. In 1938, Austria was incorporated into a terrifying German Third Reich, spreading a lot more than consternation much farther afield. Now that was all over; Austria was independent and Germany was broken—but no one was yet sure into how many parts.

There were, formally, two possibilities, one or four, but informally—and soon quite forcibly—the answer was definitely two. Technically, Germany had surrendered to the Allies, who governed the occupied country under a council of the four powers: the United States, the Soviet Union, the United Kingdom, and France. Each of those coun-

* "Barriers also stand between national and linguistic peers that prevent full communication and full mutual understanding, barriers of education, of upbringing, of talent, of individuality."

tries also controlled a separate zone (the French zone was carved out of the British one as a gesture toward European comity). Hence, the occupied zones became instantly polyglot, and there was a nationwide boom in German-English, German-French, and German-Russian dictionaries immediately after surrender.[2] For the occupying powers, communicating with each other remained fraught, especially between the Americans and the Soviets. Very few Americans knew Russian, and vice versa; communicating through a third language like German was scarcely more successful.[3]

Yet communication was essential for any kind of postwar settlement. Consider the Soviets, who set up their proxy government, the Soviet Military Administration of Germany (SVAG), on 6 June 1945 under Marshal Georgii Zhukov. Zhukov, both directly and through his deputies Colonels V. D. Sokolovskii and I. A. Serov, commanded 8,000 Soviet troops at their headquarters in Potsdam to the southwest of Berlin, supplemented by 273,000 infantry troops distributed over the entire Soviet Zone, 29,000 air force personnel, 2,700 naval troops, 20,000 special SVAG troops, and 20,000 foot soldiers of the MVD (the security services).[4] These were facts on the ground of the Soviet Zone, and at the center of that ground was the city of Berlin, split into four sectors as a microcosm of defeated Germany. One of the central concerns for the three Western powers, but especially for the Americans, was negotiating access to Berlin, which the Soviets restricted to a single highway and railway line, arguing that Soviet demobilization consumed the remaining transit points.[5] This soon became a perpetual source of conflict, triggering the Soviet closure of access to Berlin on 24 June 1948 and the subsequent Anglo-American airlift to supply the Western zones of the city with food and fuel. The Berlin Blockade was the most evident act that signaled that Germany was to become two nations: the Federal Republic of Germany in the West, and the German Democratic Republic in the East, each under the sway of the United States and the Soviet Union, respectively. Divided Berlin would become the capital of the Cold War, marked in 1961 by the erection of the eponymous Wall as literalization of the "Iron Curtain" posited by Winston Churchill in March 1946.

In the early summer of 1945, when plans for governing Germany in the short term were drawn up, that conflict lay in the future. It will come as no surprise after the previous two chapters that both Americans and Soviets governed their zones through their native tongues. Dealings in American and British offices tended to be conducted almost entirely in

English (except for a few officers who happened to speak German fluently before arriving in-country), not so much because of the ban on fraternization (rescinded, anyway, on 14 July 1945), but more because of social and economic segregation coupled with the intense hostility of some Americans toward the Germans for the Nazi rampage, mirrored by German resentment of occupation.[6]

SVAG also governed mostly monolingually in practice, although there was substantial official discomfort about the fact. SVAG leadership tried repeatedly to force officers to learn German and just as often failed. In March 1946, an order mandating German study was promulgated and rapidly ignored; out of thirty officers signed up for courses in Magdeburg, no more than a third actually came to class. Many of the Soviets who arrived already speaking German labored under a double burden: they were predominantly Jewish, and they often acquired German girlfriends (surely related to their linguistic capacities). As an anticosmopolitan campaign unfolded in Stalin's Moscow in mid-1948, fear of Jewish treason and spying led to the recall of many of these officers, purging the one set of officials on the ground who could actually speak to the locals. This was followed by more orders for German study, and more stonewalling.[7]

If Germany's politics were linguistically and politically fragmented, many Germans feared the state of science was even worse: there was nothing to fragment, for science was destroyed. Local German scientists had difficulty assessing the state of affairs because zonal barriers and censorship blocked both travel and mails, and scientific publishing had almost collapsed (exacerbated by a postwar paper shortage).[8] A foreign observer writing in the *Physikalische Blätter*, one of the new periodicals that managed to bloom amidst the rubble, painted a picture of dire need. "In addition there is the most severe lack of all scientific educational and research material," R. C. Evans wrote. "Books are not to be had, the appearance of scientific journals has been stopped, the recurring needs of a laboratory—reagents, apparatus, and everything else, even the simplest material—are almost unattainable, especially if delivery must be obtained from another Zone; the difficulties could not be greater if everything had to be obtained from abroad."*[9] Aside from the

*"Dazu kommt der schärfste Mangel an allem wissenschaftlichen Unterrichts- und Forschungsmaterial. Bücher sind nicht zu haben, wissenschaftliche Zeitschriften haben ihr Erscheinen eingestellt, Reagenzien, Apparate und jedes andere, auch das einfachste Material, der laufende Bedarf des Laboratoriums ist fast unerreichbar,

pockmarked landscape of destruction and massive displacements occasioned by the end of the war, several of the wartime leaders of German science were sitting in Allied detention pending adjudication of responsibility for war crimes. The landscape of German science began to shift; in the West, leafy Göttingen came to displace tense Berlin as the center of physics, for example. Adjusting to the postwar world entailed massive psychological and physical difficulties.[10]

Could German science recover? Part of the answer hinged on whether German as a language of science could survive the shocks of occupation. In 1951, American experts on Soviet bibliography observed that "[t]he influence of German science on Russian research in organic chemistry went down from 59 per cent at the beginning of the industrialization [late 1920s] to 30–36 per cent for the present time. The Russian chemist now uses his own literature at least as much as the German."[11] In the Soviet Union, the collapse of knowledge of the German language occasioned by the advent of the war was so severe that postwar analysts had to discard all statistics about the number of actual speakers and piece together the status quo from guesswork.[12] Meanwhile, the emerging United Nations Organization recognized five official languages—Chinese, English, French, Russian, and Spanish (Arabic was added in 1973)—noticeably leaving German behind. That seemed reasonable, for Germany was defeated and would not function as an architect of the postwar world order. But when the United Nations Educational, Scientific, and Cultural Organization (UNESCO) permitted Italian a limited status and Hindi an official one but explicitly denied any status to German—the language of great educational, scientific, and cultural achievements—it was hard to view this as anything other than punishment by the victorious powers.[13]

While the position of Germany as a country, let alone as a world power, was decidedly gloomy, many German scientists thought they might retain some cultural power for the German language through the reconstruction of German science. That science was rebuilt from the Nazi remnants not once but twice: into a West German science under an increasingly Americanizing (and Anglophone) Western scientific establishment; and into an East German variant that bore numerous stamps of its Soviet patron and that patron's language. The chapter

besonders wenn die Lieferung aus einer anderen Zone erfolgen muß; die Schwierigkeiten könnten nicht größer sein, wenn alles aus dem Ausland bezogen werden müßte."

that follows explores the development of Cold War science outside of the metropoles of the United States and the Soviet Union, chronicling the persistent decline of German as a language of science despite many heroic efforts to salvage it. In the wake of enormous infrastructural and political changes, the long and tumultuous story of scientific German appeared to be coming to a close.

Denazifying the (Mostly Western) Zone

The major mechanism of linguistic transformation throughout this book has been education, and occupied Germany was no different, though there the educational inflections were strongly colored by the unique imperatives of the denazification policy of both the Western Allies and the Soviet Union.[14] Education was a salient instance of the more general postwar reconstruction of science in the image of each superpower. The Americans were deeply invested in building a "Western" science in Europe that was strongly allied with the United States and also predominantly Anglophone. Marshall Plan aid for science, for example, was directly tied to the reorientation of the French infrastructure away from hypercentralization in Paris toward the provinces, and generally toward greater publication in English, while Columbia University physicist I. I. Rabi, a trusted science advisor, lobbied for incorporating science from nascent "West Germany" into collaborations with nations of the North Atlantic Treaty Organization (NATO).[15]

In order to accomplish Rabi's goals, one needed German scientists. The problem, of course, was reconciling the desire to have America-friendly scholars in the universities when those very institutions had been integrated into the Nazi infrastructure, staffed with party members who should at the very least be dismissed from their positions, if not tried for war crimes. (Of course some specialists, most notably rocketry engineers, were "pilfered" by both the Soviets and Americans.) The impact of denazification was massive, leading to twice as many dismissals as had Hitler's 1933 Civil Service Law, for the straightforward reason that there were many more Nazi party members in higher education at the end of the war than there had been Jews in such positions at the dawn of the Third Reich. The University of Heidelberg fired 72 instructors, Frankfurt 33, diminutive Erlangen 30 (representing a full 27% of its teaching staff), and so on down the line.[16] The six remaining major universities in the Soviet Zone—after two universities, Breslau and Königsberg, were ceded to Poland as Wrocław and the Soviet

Union as Kaliningrad, respectively—lost about 75% of their professoriate and roughly 80% of the adjunct teaching staff, a situation that was particularly aggravated in Berlin where many "clean" academics simply decamped for the West. Over 85% of the faculty who were relieved of their jobs never returned to higher education in the Soviet East.[17]

Reopening the universities was urgent, not only to return to a semblance of normality, but also to train cadres who could rebuild the future Germany (or, one should say, Germa*nies*). The remedies in the Western zones were highly varied owing to the reconstruction of the American, British, and French zones as a *federal* republic, with education a function allocated to the various states (*Länder*, in German) to resolve as each saw fit.[18] The French, for example, recognizing their inability to compete with the Americans politically or economically, emphasized the benignity of their occupation by focusing on "culture," rapidly reconstructing the Kaiser-Wilhelm Institute for Chemistry in Mainz.[19] The rector of Göttingen University after the war estimated that of the sixteen universities and eight Technische Hochschulen (higher technical schools) in the Western zones, only six were relatively unharmed, six could use 50% of their facilities, and the remaining eight were reduced to 25%–30% of their prewar infrastructure. (Münster, for example, was 80% destroyed, Munich 70%, and Würzburg 80%.) The British, in the north, were faced with perhaps the greatest devastation, since the industrial Ruhr area had suffered countless bombing runs; nonetheless, they opened all their universities by the end of 1945, beginning with unscathed Göttingen on 17 September and concluding with Köln on 12 December.[20]

West Berlin represented a unique case; its encirclement by the Soviet Zone promoted a greater degree of autonomy, leading to the most thorough overhaul of the wartime and prewar educational system.[21] The crown jewel of these efforts was the establishment in December 1948, in the midst of the Blockade, of the Freie Universität zu Berlin (the Free University in Berlin) in Dahlem, a tree-lined, somnolent neighborhood that lay right in the center of the American sector and had long been home to an elite scientific tradition. (Fission had been discovered there, for example, in 1938, and Fritz Haber's Kaiser-Wilhelm Institute for Physical Chemistry was nearby.) The Free University was largely a German-organized and German-run affair, and its linguistic emphasis was strongly German. When, after a few years, foreign students trickled in, they were required to take two semesters of German, and almost all instruction took place in that language.[22] Graduate students were

admonished that "the dissertation must be written clearly and in good German."*[23] Visiting scholars in the 1950s, on the other hand, lectured in a range of tongues—a Spanish art historian speaking in Spanish, and many in the humanities lecturing in English. The Natural Sciences Faculty, however, entertained almost exclusively talks in German, preferentially hosting Germanophone Swedes and Americans (many of them émigrés). American policy complemented the mostly grassroots German effort. Instead of deputing American professors to teach in Germany for short periods, preference was given for cycling German students to the United States for study, an ironic inversion of the interwar postdoctoral network that had been ruptured by Nazi protocols.[24]

Scientists active in occupied Germany recognized that the transformations in their country—and especially the emerging split between a communist East and a capitalist West—was beyond their control: "We are able to change nothing about this, and our journal [the *Physikalische Blätter*], that counts the cohesion and connection of German physicists as its noblest tasks, is entirely helpless against this development."†[25] In fall 1946, British authorities allowed the formation at Göttingen of a renewed German Physical Society—die Deutsche Physikalische Gesellschaft in der Britischen Zone. Max von Laue, as one of the "good Germans" who stayed within the Third Reich but did not collaborate with the regime, was made its president, while Otto Hahn was tapped for president of the Max Planck Society, the successor to the Kaiser Wilhelm Society. Both Hahn and von Laue worked within a West German context, and were—to the frustration of the occupying authorities—substantially less interested in punishing past political "mistakes" than in reestablishing a scientific community.[26] Other post–World War I institutions were adapted to this new, constrained Germany. The Notgemeinschaft was eventually transformed into the German Research Society (Deutsche Forschungsgemeinschaft), as a way of providing federal money for research without working through institutions compromised by Nazi affiliations.[27] Finally, new publications, like the *Physikalische Blätter* and the *Zeitschrift für Naturforschung*, leapt into the breach opened up by the delay in approving the denazified continuations of stalwart German journals such as the *Annalen der*

* "Die Dissertation muß klar und in gutem Deutsch geschrieben sein."

† "Wir vermögen nichts daran zu ändern, und unsere Zeitschrift, die den Zusammenhalt und die Verbindung der deutschen Physiker zu ihren vornehmsten Aufgaben zählt, ist gegenüber dieser Entwicklung völlig hilflos."

Physik and *Zeitschrift für Physik*.[28] West German science lost much of its international character. Foreign attendance at meetings of the German Physical Society, for example, began to drop off in 1950.[29] These were now meetings in German and for Germans—well, one half of the Germans.

Stalinizing (Sort of) the East

The year of the Blockade, 1948, not only marked the onset of the rapid differentiation of institutions that would make West Germany characteristically "Western," but also unsurprisingly represented the fulcrum whereupon East Germany pivoted toward Stalinization. The German Democratic Republic was crucial to Soviet designs for consolidation: it was a non-Slavic gateway to the West, a showcase for socialist progress, and an industrial engine that—after suitable reparations were bled out of the Nazi rubble—could power the communist future.[30] It was also the postwar satellite state that had the longest-standing educational infrastructure, and therefore first SVAG and later the Socialist Unity Party (SED)—the communist party that ran East Germany until its collapse—instituted more widespread changes into higher education there than anywhere else in the Warsaw Pact.[31] By way of contrast, the chemical industry retained enormous continuities with its National Socialist predecessor.[32]

The general model was to make East German higher education look like Soviet higher education, which had undergone its own Bolshevik transformation in the 1920s.[33] The consequences in East Germany, after adjusting to the tremendous personnel purges of denazification and simple outmigration, were remarkable indeed. From 1951 to 1955, there was a 463% rise in enrollments in the technical sciences in German higher education. (Lest one consider that simply an adjustment to postoccupation stability, the equivalent for the humanities was only 112%.)[34] The Prussian Academy of Sciences was also entirely refashioned, shifting from an all-German honorific institution to a fully socialist research academy by 1969. In part to counter the visible success of the Free University, the Academy and the University of Berlin—renamed Humboldt University—were endowed with massive resources to promote research and collaboration with an eye toward technological applications and economic growth. Comprising only 131 staff members in 1946, the Academy's payroll reached 12,923 by 1967, and almost

doubling again by the moment of collapse in 1989.[35] The East Germans also erected a parallel scientific publication infrastructure to counterbalance the torrent of periodicals and technical books emanating from West Germany: separate professional journals begin to appear in 1951, university journals the following year, and the year after that the ubiquitous Deutscher Verlag der Wissenschaften (German Publisher of the Sciences).[36]

The linguistic hiccups that had hampered SVAG's operation did not magically disappear. Soviet officials neither knew much about German education nor understood the language, so almost all negotiations happened in rudimentary pidgin. When Soviet experts came on lecture tours, even well into the 1950s, they spoke in Russian before uncomprehending audiences; translators had to be rousted at the last minute.[37] On the other hand, those East Germans who did master Russian could attain significant professional advancement.[38] There were, to be sure, some benefits to the stubborn insistence of East Germans on speaking German—it meant they could converse with West German colleagues, blossoming into a vital conduit for the thriving East German specialty of industrial espionage.[39]

Nonetheless, it simply would not do to have the Germans speaking German to the exclusion of everything else. Science, like communism, was international, and surely it would be to the advantage of citizens of the German Democratic Republic if they could access the tremendous contemporary advances in Soviet science. In the case of socialist friends, much like that of the capitalist enemies, the key to learning what the Soviets knew was learning their language. The Soviet leadership was particularly keen to encourage this ambition throughout its sphere of influence. Russian quickly became the first foreign language taught in Eastern Europe. In Hungary, for example, eight years of Russian soon became compulsory and remained so until 1989. The same was true everywhere else, with the exception of Romania, where Russian ceased to be obligatory in 1963; French returned to its traditional place in Romanian education, being preferred to Russian or English by 60% of students.[40]

East Germany was more like Hungary than Romania, and like Hungary the obligation to study Russian did not imply actually *learning* it. As always, some did become enthusiastic about the language, as in this statement drawn from a proposal for a Russian-German dictionary in 1961:

> Russian is one of the leading world-languages. This fact is to be explained through the role of the USSR as a world power and the prestige that it possesses thanks to its achievements and successes in the political, scientific, technical, economic, and cultural arenas as well as in the field of sports. The worldwide interest that is shown to the Russian language grows constantly. Russian is first of all the most important negotiating language of the socialist camp (COMECON, Warsaw Pact, etc.). The Russian language is of an entirely particular significance for the GDR. The necessity of knowing Russian arises for a great part of the population of the GDR objectively from the tight, constantly deepening cooperation and friendship with the Soviet Union.*[41]

Attempts to institute Russian-language pedagogy began with the occupation. SVAG established Slavic Departments in universities across the Soviet Zone, with the explicit aim of producing a team of ready translators from Russian into German (not, generally, vice versa). Translation was also the goal of the Academy of Sciences, whose Institut für Dokumentation began churning out renderings of Russian technical treatises in dry German in 1954.[42] One needs translators only when knowledge of the language is lacking, and Russian did not seem to take (surely at least in part because some identified it as the language of invading occupiers, and understood their own failure to assimilate it as a mark of resistance). Nonetheless, efforts to inculcate the language persisted. In 1958, the Academy of Sciences ran 22 courses with 215 participants; in 1962, it was supporting 37 courses with 370 students.[43] These were all individuals within the Academy hierarchy, and who therefore had passed through higher education. That meant they should have *already* learned the language, since in 1951 it became obligatory in universities, swelling the rosters in Russian classes and generating administrative head-

*"Russisch ist eine der führenden Weltsprachen. Diese Tatsache ist durch die Rolle der UdSSR als Weltmacht und ihr Prestige zu erklären, das sie dank ihrer Leistungen und Erfolge auf politischem, wissenschaftlichem, technischem, wirtschaftlichem und kulturellem Gebiet sowie im Bereich des Sports besitzt. Das weltweite Interesse, das der russischen Sprache entgegenbracht [sic] wird, steigt ständig. Russisch ist vor allem die wichtigste Verhandlungssprache des sozialistischen Lagers (RGW, Warschauer Pakt usw.). Von ganz besonderer Bedeutung ist die russische Sprache für die DDR. Die Notwendigkeit der Kenntnis der russischen Sprache ergibt sich für große Teile der Bevölkerung der DDR objektiv aus der engen, sich ständig vertiefenden Zusammenarbeit und Freundschaft mit der Sowjetunion."

aches.[44] Yet it seems that Russian's impact on the East was rather less significant than English's on the West, in large part because English was also a high-prestige language in the GDR.[45]

In the archives of Humboldt University, the flagship of East German higher education, one can find numerous traces of the struggle to drill perfective verbs and instrumental cases into the heads of reluctant Teutons. In a policy statement of 1957, "foreign language" collapsed into "Russian language" instruction in the space of a breath:

> For modern specialist training the knowledge of at least two world-languages is indispensable.
>
> From the viewpoint of the national interests of the German people and of the further development and flourishing of German science, technology, and culture, knowledge of the Russian language is an absolute necessity for those training specialties at the universities and higher schools. In the same way it is important in the interest of the development of German science, culture, and technology that the scientific, technical, and artistic disciplines assimilate the achievements of other peoples and acquire the knowledge of other world-languages.*[46]

As of 6 June of that year, instruction in Russian as well as another "Weltsprache" (here meaning English, French, Italian, or Spanish) was obligatory, although Russian was substantially emphasized. (One should not assume that the quality of instruction was particularly high. The archive is littered with complaints about the poor level of English teaching, for example.[47]) These languages, however, were not to be learned at the expense of German. As at the Free University in the West, foreign students—in the case of the Humboldt mostly from the Eastern bloc—necessitated making explicit something that had been obvious since the eighteenth century: "German instruction is obligatory for such foreign

*"Für die moderne fachwissenschaftliche Ausbildung ist die Kenntnis von mindestens zwei Weltsprachen unerläßlich.

Vom Gesichtspunkt der nationalen Interessen des deutschen Volkes und der weiteren Entwicklung und Blüte der deutschen Wissenschaft, Technik und Kultur ist die Kenntnis der russischen Sprache für die an den Universitäten und Hochschulen auszubildenden Fachkräfte unbedingte Notwendigkeit. Ebenso ist es im Interesse der Entwicklung der deutschen Wissenschaft, Kultur und Technik wichtig, daß sich die wissenschaftlichen, technischen und künstlerischen Fachkräfte die Errungenschaften anderer Völker aneignen und Kenntnisse in anderen Weltsprachen erwerben."

students and will be taught in the first year of study with six hours per week, in the second year of study with four."* [48]

In 1956 the Humboldt administration commissioned a poll of roughly 150 institutions and departments housed within its walls to see what the most important foreign languages for the various branches of science were, in hopes of allocating its resources accordingly. Even accounting for the biases in data collection and the obvious political skewing of the results, this poll provides a unique snapshot of scientific languages in Berlin—once the epicenter of European science—at the moment the decline of German could no longer be ignored. Of the 100 responses returned, representing 87 disciplines, fully 64 selected English and 42 Russian as "absolutely [necessary]" (*unbedingt*) for mastery of the subject matter of the field. (The remaining numbers were 39 Latin, 17 French, 11 Greek, and 7 Hebrew. One should keep in mind that the German *Wissenschaft* is a more copious term than "science," and that several disciplines selected more than one language.) When asked which languages were also "desirable" (*wünschenswert*), another 23 added English—bringing the number up to the full 87—along with 35 Russian and 55 French. A potpourri of other languages graced this other category, including Italian, Spanish, Danish, Swedish, Norwegian, modern Greek, Polish, and Czech. The results were unequivocal: "*In sum therefore the chief languages appear to be English* 87 x, *Russian* 78 x, *French* 72 x, *Latin* 61 x, *Ancient Greek* 15 x."† [49]

When zeroing in on the Faculty of Mathematical and Natural Sciences, comprised of 17 disciplines, the picture was even more striking. English was required in every single department, Russian was required in eight and optional in the rest, and French and Latin trailed significantly (required in three and two departments, respectively).[50] Adding the fifteen disciplines in the medical faculty raised the figures for Latin (required in 13), but also boosted English (required in eight) at the expense of Russian (only two).[51] The most surprising feature of these numbers is the enthusiasm for Latin, backed even by the chemists.

If German were going to survive as a language of science against the tropical storm of Russian or the hurricane of English, whether in the Proletarian East or the Bourgeois West, it was going to need a different strategy than simply business as usual. Unless, that is, the first-mover effect of having once been the dominant language of chemistry could be exploited to maintain a foothold for German among the world's scientists. The solution might be to emphasize not cutting-edge contemporary research, but rather the much less glamorous domain of the stodgy reference work.

*"Der Deutschunterricht ist für solche Auslandsstudenten obligatorisch und wird im ersten Studienjahr mit sechs, im zweiten Studienjahr mit vier Wochenstunden erteilt."

†"*Insgesamt erscheinen also die Hauptsprachen Englisch* 87 x, *Russisch* 78 x, *Französisch* 72 x, *Latein* 61 x, *Altgriechisch* 15 x."

Shackled by Abstracts

No chemist has ever read the entire *Chemisches Zentralblatt*, but for well over a century not a single practicing chemist was able to conduct research without it. Founded in 1830, the *Zentralblatt* was the oldest abstract journal in chemistry, offering summaries of what its editors considered to be the most relevant chemical literature. In its very creation, the journal embodied a dominant anxiety of scholars since at least the Renaissance (and likely earlier): there was simply too much to read.[52] Until 1907, when the American Chemical Society assumed control of *Chemical Abstracts*, there was no plausible competitor to the *Zentralblatt* for controlling the torrents of chemical literature, and the American outfit did not become the leading abstract journal until roughly World War II. Thus, the *Zentralblatt* tracks in miniature the rise and then eclipse of German chemistry, and of German as a scientific language.

When the *Zentralblatt*'s first editor, Gustav Theodor Fechner, decided to hang up his spurs in 1834, the journal included roughly 500 abstracts on 950 pages—a hefty tome, true, but also rather wordy abstracts. The journal chewed up a series of editors in the middle years of the nineteenth century, and also shed the references to pharmacy included in its original title. In 1870, the year before the unification of Germany into a powerful nation-state, the format and typesetting were overhauled to account for the journal's continued expansion. Between 1886 and 1887, for example, the contents ballooned from 860 to 1,580 pages, representing abstracts culled from 273 chemistry journals. In 1895, sixty-five years after its inception, the journal seemed too unwieldy, too cowed by the mushrooming researches appearing in ever larger numbers (and numbers of languages) to be continued as a private business venture. The German Chemical Society agreed to bring the journal in-house, and that is where it stayed as the German polity itself underwent shock after shock. In 1929, in an article celebrating the

Zentralblatt's centenary, the language barrier was singled out: "This exchange will only succeed, even with the best intentions of all involved, if all of us in Germany, France, England, America, and in other countries devote more attention and industriousness to foreign languages."* [53] Before World War II, the journal had expanded again by almost 52%. German chemistry may have been largely cut off from the rest of the world during the Third Reich, but foreigners still followed the global literature through the *Zentralblatt*, edited by Maximilian Pflücke in the Hofmann Haus in Berlin. In 1944, a bomb careened into the heart of the building, leaving only rubble. In 1945, the last volume of the *Zentralblatt*, already at the printers, appeared. The journal, like unified Germany, was dead.

Like Germany, it would rise again, curiously schizophrenic. When the fog of the postwar settlement began to dissipate, officials and chemists looked about them and realized that the *Zentralblatt* had gone into abeyance. It had to be revived, declared a top official at the Academy of Sciences: "The reappearance of the *Chemisches Zentralblatt* is necessary if German chemical industry and research are to come up to speed."† [54] But how to do it? The *Zentralblatt* was a production of the German Chemical Society based in Berlin, but no one knew which occupying power controlled it. The Society's headquarters had been located in what was, in 1947, the British Sector of the city, but the editorial offices had been whisked away to the American enclave of Dahlem at war's end. The publisher, Verlag Chemie GmbH, had also once resided in the British Sector but had moved to the American because of war damage. It seemed as though the Americans were going to sponsor the *Zentralblatt*.[55]

The Soviets—or, rather, German chemists in the Soviet Zone—begged to differ. Since the Academy of Sciences was in the Soviet Sector and had on hand a group of former *Zentralblatt* collaborators, it began to put out the 116th volume in 1946, although licensing red tape held it up. In November 1946, the Americans granted Verlag Chemie the authority to publish the journal; the following year the Academy (under authorization from SVAG, issued on 1 July 1947) commissioned

*"Dieser Austausch wird auch beim besten Willen aller Einsichtigen nur gelingen, wenn wir alle in Deutschland, Frankreich, England, Amerika und in den anderen Ländern den Fremdsprachen mehr Aufmerksamkeit und Fleiß zuwenden."

†"Das Wiedererscheinen des Chemischen Zentralblattes ist notwendig, wenn die deutsche chemische Wissenschaft und Forschung in Gang kommen soll."

its in-house Akademie Verlag to do the same. What had once been one unwieldy journal had now become two. "Until the resolution of the matter," wrote Georg Kurt Schauer from Frankfurt am Main, solidly in the American Zone, to the administration of the Akademie Verlag in the East in October 1947, "which the allied command of the occupying powers has reserved for itself, the strange state will continue that one scientific journal will be published by two different publishers, with two different editorial boards and staffs of collaborators, with the same numbering of the volumes in the earlier traditional form."* [56]

There was also a problem with Maximilian Pflücke, editor of the periodical since 1923, who had joined the Nazi Party in 1933. Denazification officials sometimes went easy on individuals who joined for purely opportunistic reasons, and Pflücke might have earned an exemption had he been able to demonstrate the shallowness of his political conviction; unfortunately for him, "he was also actively occupied in a fascist sense during the Nazi regime."† [57] He could hold no public position—and editorship definitely qualified—in the Soviet Zone. But the emergence of the American *Doppelgänger* softened opinions. "[N]ow also upon the existence of a published 'Chemisches Zentralblatt' under an American license," an official noted in 1948, "it seems to us especially important to allow Dr. Pflücke to step in from outside in order to announce that our journal is the old classic 'Chemisches Zentralblatt' under the tried-and-true leadership of 35 years."† [58] Nazi or no, Pflücke provided the semblance of continuity which might confute the Americans' claims.

The resolution might very well have resembled the macroscopic outcome: a seemingly permanent division between East and West, with parallel publications mirroring parallel societies. In the event, however, the chemists and scientific publishers opted in 1949 for what had proven unworkable politically. There would be two Germanies, but one

*"Bis zur Entscheidung des Falles, den die alliierte Kommandatur den Besatzungsmächten vorbehalten hat, besteht der seltsame Zustand weiter, dass eine wissenschaftliche Zeitschrift von zwei verschiedenen Verlagen, mit zwei verschiedenen Redaktionen und Mitarbeiterstäben, mit gleicher Bandzahl und Numerierung in der früheren traditionellen Form herausgebracht wird."

†"hat sich auch während des Nazi-Regimes aktiv im faschistischen Sinne betätigt."

†"jetzt auch auf das Bestehen eines unter amerikanischer Lizenz herauskommenden 'Chemischen Zentralblatts' erscheint es uns als besonders wichtig, Herrn Dr. Pflücke nach aussen hin in Erscheinung treten zu lassen, um so zu betonen, dass unsere Zeitschrift das alte klassische 'Chemische Zentralblatt' unter der 35 Jahre bewährten Leitung ist."

Zentralblatt. Hans Brockmann at Göttingen—an organic chemist who had also joined the Nazi Party in 1933—and Erich Thilo of the Berlin Academy erected a joint *Zentralblatt*, to start appearing as of 1 January 1950. The final compromise established Pflücke as the head of the Eastern office, Eugen Klever as the head of the Western office, and Pflücke as the editor-in-chief, the whole affair organized as a joint East-West production sponsored by the German Chemical Society, the Berlin Academy of Sciences, and the West German Academy of Sciences in Göttingen. (This at a time when West Germany refused to recognize that the German Democratic Republic even existed.) Immediately, Pflücke and his collaborators tackled the enormous backlog that had accumulated, and sixteen supplementary volumes had to be prepared between 1950 and 1954 to clear the docket for business as usual.[59] By 1966, the Berlin Academy proudly lauded the *Chemisches Zentralblatt* as its most important publication.[60] Three years later, it was dead.

The cause of death was both too many languages and one language in particular. Chemists had worried about the mounting linguistic burden for decades, but by the mid-1950s even the stalwart Pflücke wondered whether one could maintain a monolingual abstracts journal in a polyglot world. True, the importance of German was buttressed for a few more years by the fact that chemists worldwide had to consult the *Zentralblatt*, but preserving that German character imposed huge costs. One had to either tame the languages through selective abstracting, or somehow defray the labor costs imposed by the gamut of 36 languages covered by the *Zentralblatt*.[61]

The problem with the one language, English, was obvious. Before World War II, a sizeable chunk of the world's chemical output had been in German. Now that English was swamping something approaching 65% of world publication in chemistry, the German labor force either had to be trained up in this one language, or Anglophone collaborators had to be brought on board—and it was hard enough to maintain the delicate balance of East and West German cooperation in the years before Willy Brandt's *Ostpolitik* (1969–1974) began to normalize relations between the Germanies. The American-run *Chemical Abstracts* faced the inverse of this situation, as the mounting tide of English made their job linguistically *easier* each year. In 1957, the *Abstracts* published 24,600 entries, 41.3% more than the same year's *Zentralblatt*.[62] Two years later, the seventy-year-old Pflücke retired, and Heinrich Bertsch and Wilhelm Klemm attempted to bail out the ship. They succeeded for one more decade. By the 1980s, the infrastructure that had been

dedicated to putting out the titanic abstract journal was folded into an input service for *Chemical Abstracts* and a fee-for-service bibliographic resource for industry.[63] If reference works were the best hope to staunch the hemorrhaging of chemical German, the East-West joint venture was not going to get the job done. The West Germans would have to save German on their own.

The Beilstein Gambit

In a wide variety of contexts, West Germany assumed the burdens of prewar Germany. The role of economic juggernaut, the center of intellectual political culture, the guilt and shame of the Holocaust—the Federal Republic of Germany shouldered these as it embarked on the economic miracle, the *Wirtschaftswunder*, of the 1950s. While English began to assume an ever greater role in internal education within West Germany, the government attempted to keep some distance from the Americans driving the development. If English had to be taught, it was going to be British English, and Bonn also continued an assiduous program of promoting the German language abroad that had started with the nineteenth-century *Kaiserreich*.[64] Russian was a significantly smaller concern, although no scientifically active country could completely ignore the language. The West Germans followed the American cover-to-cover journals closely, and also set up some translation ventures and review journals of their own to render Soviet achievements legible on the near side of the Iron Curtain.[65] When West Germans thought about preserving German as a language of science, the enemy was English, and the home of scientific English was now the United States.

The makers of West German science policy undertook two major campaigns to preserve the importance of their country as a scientific metropole and, consequently, their language as an essential mode of communication: one centered on personnel, and one on publication. Today, the problem with personnel would be called "brain drain," but no one labeled it that in the 1950s. In truth, it was not a new phenomenon, but rather a continuation of the bleeding that had begun with the economic crises of the 1920s and the 1933 Civil Service Law. German scientists were leaving Central Europe and heading to sunnier climes, principally the United States; afterward, they tended to speak and publish in English. The German Research Council estimated that between 1950 and 1967, about 1,400 scientists were lost from West Ger-

many through outmigration.[66] Internal estimates by the Max Planck Society—the leading research establishment in the country—were even graver: between 1957 and 1964, it counted 973 natural scientists out of a total of 3,400 scientists and engineers who had emigrated to the United States alone.[67] It seemed, however, that by 1968 the flow out had been balanced by economic émigrés returning to assume jobs within the Federal Republic.[68] This was the result of an active plan to recruit émigrés whenever high-level posts became available, securing the best and brightest for German science.[69]

That, however, would only preserve German-speaking science for German speakers. How might one persuade foreign scientists to learn the language? The obvious answer, to those at the Max Planck Society, was to follow what had convinced past generations of foreign scientists to learn German: provide them with a quality product they could access only in the language. The most explicit instantiation of this strategy had its roots in Imperial Russia in the 1860s and 1870s, born of the very characters we first met in the stormy priority dispute over Dmitrii Mendeleev's periodic system.

It is the tale of a man who became a book, a very large and important reference work that became indispensible for practicing organic chemists for about a century. The man was Friedrich Konrad Beilstein, and we first encountered him as an editor of the *Zeitschrift für Chemie*, the one charged with translating Mendeleev's Russian-language abstract into German for foreign consumption, and who botched the affair by entrusting it to a graduate student. Beilstein was born in St. Petersburg in February 1838 to a family of German-speakers who had migrated eastward to try their fortunes in the growing Imperial capital. Raised bilingually, he acquired several more languages during his later scientific training in the German states, eventually securing a post at the University of Göttingen before he was summoned back to St. Petersburg's Technological Institute in 1866, an offer he accepted to succor his family after his father's sudden death. Beilstein thrived in St. Petersburg: he retired with honors from the Technological Institute and was elected to the Imperial Academy of Sciences in 1886. Yet it was a difficult environment for him—he felt isolated because of his German name, habits, and language in an increasingly nationalist environment.[70]

He turned that isolation to good purpose, converting the organic chemistry textbook he had been working on into an index of all carbon-containing molecules that had yet been discovered, complete with detailed properties and accurate citations to the relevant scholarly literature. The first volume of his *Handbuch der organischen Chemie* (*Handbook of Organic Chemistry*) appeared in 1881, a two-volume behemoth consisting of 2,200 pages and detailing roughly 15,000 organic compounds.[71] It instantly brought him accolades from across Europe. (Nearer to home, however, the nationalist gibes would not stop. As he wrote to Heinrich Göppert in 1881: "Even *the* fact that my large just-published *Handbuch der organischen Chemie* appeared in the *German* language (buyers would be lacking for a Russian work) brought me the censure of the patriots."[*72]) Immediately, Beilstein turned to work on a second edition, which appeared in three volumes between 1886 and 1889. The third edition of 1893–1899, spanning 6,800 pages and an additional 50,000 compounds, consisted of four tomes, and Beilstein had had enough. There were too many new organic molecules being discovered, the literature was unimaginably vast, and he was growing old.

So this project, begun as a lone venture by a Germanophone scientist living in the Russian capital, was catapulted to the heart of Berlin. In 1896 Beilstein began to make arrangements for the German Chemical Society to undertake the publication of future editions, and he deputed Paul Jacobson, then 36 years old and soon to be appointed as the general secretary of the Society, as editor.[73] Not everyone was happy with the arrangement; Jakob Volhard, for example, argued that "[i]n my opinion, one would better leave both the *Beilstein* and the *Centralblatt* to private industry. But Beilstein was so hot and heavy for this plan that the further editions would be edited by the Chemical Society that there was no setting out of reasons against it[. . .]."[†74] Beilstein died in 1906, pleased that his magnum opus would live on. In 1914 the Society in turn entrusted the printing of the fourth edition, due to contain all molecules discovered before 1 January 1910, to the Springer publishing firm. That same year, of course, the Great War erupted.

Amazingly, the war had very little impact on the progress of the *Beilstein*, as the book came to be universally known. By the middle of 1916, the entire file of material for the fourth edition was assembled in 123

*"Selbst *die* Thatsache, daß mein so eben erscheinendes großes Handbuch der organischen Chemie in *deutscher* Sprache erscheint (für ein russisches Werk würde es an Abnehmern fehlen), hat mir den Tadel der Patrioten zugezogen."

†"Sowohl den Beilstein als auch das Centralblatt hätte man meiner Meinung nach besser der Privatindustrie überlassen. Aber Beilstein war so Feuer und Flamme für diesen Plan, daß die weiteren Ausgaben von der chemischen Gesellschaft herausgegeben werden, es war kein Aufkommen mit Gründen dagegen[. . .]."

fireproof filing cabinets in Hofmann Haus (the same location as the *Chemisches Zentralblatt*), with a photograph of the entire manuscript for backup. The first volume was sent to the printers that November, and it was completed by 1918 despite a paper shortage.[75] Though the Entente fumed about the dominance of German science, *Beilstein* was specifically cited in April 1918 as a reason why "a reading knowledge of German, with French if possible," was required for a chemist.[76] An attempt to translate *Beilstein* into French in the interwar period self-destructed.[77] As German chemists became pariahs in the wake of the Boycott, Jacobson hoped that "[m]aybe it is granted to the 4th edition[. . .] to assume for itself [the task] and thus help peoples to come closer to each other on a common path in the pursuit of scientific progress!"*[78] He died in 1923, three years before the boycott was rescinded. Jacobson's long-time collaborator Bernhard Prager was now joined by Friedrich Richter, who oversaw the appearance of the final (27th!) volume of the fourth edition in 1937. The stormiest period of *Beilstein*'s existence was just about to begin.

Prager was summarily dismissed in 1933 on political grounds; he died the following year. Six Jewish collaborators were also sacked, and Richter feared he could not keep to his publication deadline and begged the board to postpone further dismissals until 1936. That year and the following, four central employees and five additional workers of Jewish extraction were fired. Losing 30% of its total staff (28 in 1933 and 31 in 1937, including the editor) was crippling.[79] Richter kept his skeleton crew working throughout the war, although they abandoned Hofmann Haus in 1943 because of air raids—presciently, given the devastation the following year that caught the *Zentralblatt* unawares—and carried their library to Zobten, near Breslau in Silesia. The staff, burdened by their massive library, then retreated before the encroaching Red Army and settled in Tharandt until January 1945, when Soviet incursions forced them back to Berlin. The Americans happily welcomed them in July and set them to work.

Beilstein moved into the former offices of the Kaiser-Wilhelm Institute for Biology. By 1946, the staff had been reduced to a paltry seven people. In 1951 the rechristened "Beilstein Institute for the Literature of Organic Chemistry" had built up to a healthy complement of 39,

*"Vielleicht ist es der 4. Auflage beschieden[. . .], auf sich zu ziehen und daran mitzuhelfen, daß die Völker sich einander wieder in der Verfolgung des wissenschaftlichen Fortschritts auf gemeinsamen Wegen nähern!"

newly settled far away from the Soviets and East Germans in Frankfurt-Höchst, and moving six years later into the newly constructed Carl-Bosch-Haus in Frankfurt am Main itself.[80] All of this cost a good deal of money, and resources were hard to find in postwar West Germany. As the official history of the International Union of Pure and Applied Chemistry (IUPAC) noted, "there was a widely held view that these publications"—*Beilstein* and its sister for inorganic chemistry, the *Gmelin*—"were regarded by some nations as spoils of war; thus it was vital that the Union should take an active part in ensuring that the whole chemical community could benefit from information gathered by their editorial staff."[81] The financial burden was massive, but the elites who crafted science were convinced—just as they had been after World War I, but with perhaps a greater degree of urgency—that *Beilstein's* "role as a German bearer of culture abroad today is of especial significance for us Germans[. . .]."*[82]

Beilstein could bring redemption, and who better to offer it than Otto Hahn, recent Nobel laureate for the discovery of fission and a "good German" who had weathered the Nazi onslaught with minimal compromises to his good name. As the new president of the Max Planck Society, Hahn was willing to adopt *Beilstein* if he could thereby stave off the collapse of German as a scientific language. He wrote to the Ministry of Economy in 1952 for 83,000 Deutschmarks (about $177,000 in 2014 dollars—a princely sum in the circumstances) to be disbursed to the Beilstein Institute. "Precisely the fact that a standard work of chemistry appears in the German language is of especial value for the return to recognition of German in the scientific field," he explained. "I have often sadly had to notice that precisely the retreat of the German language at international congresses has in the end damaging effects for the economy and for the image of Germany in general. It seems to me therefore especially desirable that the Beilstein Institute, the leader of which enjoys the greatest recognition and esteem, also receives further support from the part of your ministry."†[83]

*"Für uns Deutsche ist seine Rolle als deutscher Kulturträger im Ausland in der heutigen Zeit von besonderer Bedeutung[. . .]."

†"Gerade die Tatsache, dass ein Standardwerk der Chemie in deutscher Sprache erscheint, ist für die Wiedergeltung der deutschen Sprache auf dem wissenschaftlichen Gebiet von besonderem Wert. Ich habe oft leider feststellen müssen, dass gerade der Rückgang der deutschen Sprache auf internationalen Kongressen sich letztenendes auch schädlich für die Wirtschaft und für das Ansehen Deutschlands überhaupt auswirkt. Es scheint mir deshalb besonders erwünscht, dass das Beilstein-

Hahn understood that working chemists needed to consult *Beilstein*'s hefty volumes constantly, and to do so they needed at least a modicum of German. A whole raft of handbooks were produced—some in German, some in English, many bilingual—to teach the uninitiated enough "*Beilstein* German" to make headway.[84] Springer distributed a slim 2,000-word dictionary free of charge.[85] In the end, one English guide pointed out, "even students whose ability to cope with the German introduction is very meager will be found to have little difficulty with the technical vocabulary of the main part of the work."[86] As long as *Beilstein* was indispensible, so was the German language.

But all was not quiet on the European scientific-publishing front. In 1950 Elsevier—Springer's Dutch arch-competitor—announced that it was contemplating putting out an encyclopedia in organic chemistry, duplicating much of *Beilstein*, in English. (Ironically, the project was itself an outcome of the exile of German chemists; fired and displaced employees of *Beilstein* would form the core of its work force.) Hahn convened a meeting in Frankfurt to discuss the implications and insisted repeatedly that *Beilstein* must remain in German in order to retain the support of his Society. "Besides," he continued, "it would be good if the 'American boys' at least still had in *Beilstein* the opportunity to practice German. Such a work would be *good* propaganda for Germany."*[87] Dr. R. Fraser of UNESCO, who attended the meeting, also insisted that "the Beilstein in any event will be published in the German language. Not just for the reason that thus the 'American youth' will learn German, but because Beilstein has always been a German undertaking and it belongs to the German language."†[88] Richter, the Third Reich's *Beilstein* editor and now also West Germany's, lamented that "interest in and knowledge of the German language abroad has greatly fallen off." Would *Beilstein* save scientific German? "In the end," he continued, "decisive for the sales of the Beilstein Handbuch is however the high quality that will retain for the Handbuch its uniqueness and indispensability."*[89] *Beilstein* would remain German.

Institut, dessen Leiter international grösste Anerkennung und Wertschätzung geniesst, auch von seiten Ihres Ministeriums eine weitere Unterstützung erfährt."

*"Ausserdem waere es gut, wenn die 'American boys' wengistens noch im Beilstein Gelegenheit haetten, sich in der deutschen Sprache zu ueben. Ein solches Werk waere eine *gute* Propaganda fuer Deutschland."

†"der Beilstein auf alle Faelle in deutscher Sprache gedruckt wird. Nicht gerade aus dem Grunde, damit die 'amerikanischen Jungens' auch Deutsch lernen, sondern weil Beilstein immer ein deutsches Unternehmen gewesen ist und es zur deutschen Sprache gehoert."

Until 1981, when it was decided to render all future volumes of *Beilstein* in English.[90] By then, the Beilstein Institute had expanded to a staff of 160, 110 of whom possessed a PhD in chemistry, and their work was supplemented by roughly 350 outside contributors (mostly West Germans) who had a higher degree in chemistry. These individuals understood the shape of the chemical literature, saw the almost miniscule contribution that appeared in German, and bowed to what seemed inevitable. On 1 April 1978, Reiner Luckenbach succeeded H. G. Boit as editor of *Beilstein*, and he moved what had been a personal project of a nineteenth-century subject of the Tsar into an avatar of the digital age.[91] *Beilstein* was plagued by delays and exorbitant prices as long as it stayed a serial monograph. Shifting, albeit slowly, to an electronic search engine resolved a host of orthographic and especially language-barrier difficulties and made the high price tag—by the 1990s, it cost more than $30,000—worth the investment.[92] In 1998, a chemist who had been using *Beilstein* for decades applauded the transformation; while piecing together the components of a reaction had once been a tiresome slog through hardbound volumes, "now those activities take a few seconds, because the database is computerized and the information is essentially all in English."[93]

Götterdämmerung

One would not recognize in today's *Beilstein* any of the traces of this long and complex trek through the history of scientific German. After the end of the Cold War, with the breaching of the Berlin Wall in November 1989 and the reunification of Germany the following year, the Beilstein Institute remained in Frankfurt am Main but the entire enterprise "remade itself into a commercial venture, and it is run as a business, in a most businesslike manner," to quote one commentator. "Virtually nothing but the name and high quality are the same after this massive reorganization effort."[94] While it had once been funded by Springer and the German state, the efforts of the Institute were now en-

*"das Interesse an der deutschen Sprache und ihre Kenntnis im Ausland sehr zurückgegangen seien. Letzten Endes entscheidend für den Absatz des Beilstein-Handbuchs sei aber eine hohe Qualität, die dem Handbuch seine Einmaligkeit und Unentbehrlichkeit wahren werde."

tirely controlled by a private company, Information Handling Systems, complete with a new bureaucratic structure. The name of the informational service changed accordingly. With full computerization, the system was dubbed "CrossFire Beilstein," and in 2009 its content was subsumed into Elsevier's "Reaxsys," its German origins subsumed within a trademark neologism of the age of globalization.

The stories in this chapter have been episodic, tacking between institutions, publishing ventures, abstract journals, and countries, but each occupied the same territorial space, often only a kilometer or two apart in the center of the city that defined for much of the Northern Hemisphere the meaning of "Cold War." Told through the eyes of scientists who (for the most part) sincerely believed that they worked above ideology and outside of narrow geopolitical interests, the narrative differs from conventional stories of the Cold War. There aren't many spies and there is surprisingly little overt grandstanding, but nonetheless the choices made by Otto Hahn with *Beilstein*, the East German academy with the denazification of Pflücke, the universities East and West as they struggled to staff their courses and simultaneously adapt to a new, post–Third Reich Germany (and, eventually, Germanies), relate a story of Europe for the modern age. Scientific German provides a less dramatic take, granted, than John Le Carré or Ian Fleming might have, but perhaps that is because the ordinary life of scientists attempting to reconcile with the past, communicate with their present peers, and plan for the future represents the lived reality of the Cold War for the vast majority.

Not only was the state of scientific German hard to characterize by the end of the 1970s, so was German itself. Always a pluricentric language—think of the distinctions between German in Berlin and in Munich, in Dresden and in Köln, not to mention Austria (Salzburg vs. Vienna), Switzerland, Lichtenstein, Pennsylvania German, and so on—the surprising stability of the Cold War prompted discussion of the division of German itself. A vigorous sociolinguistic debate grappled with the question of whether East and West German were becoming two distinct dialects or even languages. Given the ideological context of the times, it is unsurprising that characteristic patterns emerged, with East Germans highlighting variations not only in lexicon but also in syntax to argue for the development of a distinctive socialist culture, and West Germans attempting to minimize these as unimportant variations in the face of a common linguistic bond.[95] By the 1970s, this debate had become like the Cold War: static and without resolution.

The fuzzy national status of German—in the postwar period, it was an official language in six countries and enjoyed subordinate (minority or regional) status in Belgium, Italy, and Namibia besides—was to some extent an advantage. German was a capitalist language, as represented by the Federal Republic. It was a socialist language, as evidenced by the Democratic Republic. It was politically neutral, thanks to Switzerland. It enjoyed, therefore, a marked capacity to serve as a passport between different worlds, facilitating a resurgence of the language as a vehicle for international trade.[96] For many, however, hopes for the rehabilitation of the language to its former international dominance rested with science, for this was an area (unlike politics or economics) where German dominance was not resented in the contemporary world, and in which the achievements of the past retained value. The rare optimistic article proclaiming a renaissance in German to lie right around the corner would always cite science—the Max Planck Society, the excellent universities, the prestigious journals and publishers—as the vehicle for future growth.[97] More realistic sociolinguists, however, recognized that the state of German in the sciences was locked into a zero-sum relationship with English. As Ulrich Ammon, the foremost scholar of the present-day status of German as a scientific language, noted in 1990: "the ground lost by German has been gained virtually exclusively by English."[98] There is no other place to bring our story to conclusion than the language in which it has been written.

CHAPTER 11

Anglophonia

> The language in which we are speaking is his before it is mine. How different are the words *home, Christ, ale, master*, on his lips and on mine! I cannot speak or write these words without unrest of spirit. His language, so familiar and so foreign, will always be for me an acquired speech. I have not made or accepted its words. My voice holds them at bay. My soul frets in the shadow of his language.
>
> JAMES JOYCE[1]

On New Year's Day, 2012, science reached the end of its Latin. As of that date, the International Code of Botanical Nomenclature, the official record of plant species, declared as no longer obligatory the long-established practice of requiring not only that the Linnaean binomial classification, but also the description of candidates for new species (how many stamens, the shape of the leaves, and so forth) be in Latin. You could still submit descriptions in Latin if you wished—perhaps to keep up skills from primary school, or to continue a pleasant association with the classicists across campus—but from this date onward English would also be acceptable. Descriptions in Latin became a requirement in 1906, in response to a request by Spanish botanists to allow their language as legitimate for botanical diagnoses alongside French, English, German, and Italian. The reaction was predictable: to avoid an incipient Babel of too many languages, the international organization insisted upon the language of the Romans, perceived as neutral. The custom was reaffirmed in Article 37 of the International Code, published in 1961. And now, in 2012, Latin was perceived as unwieldy and backward, and the new language of neutrality was one of the very tongues the Spanish delegates had protested: English.[2] This outcome is probably no surprise to you. The only question is why it took so long.

Today, English is not only the dominant form of international scientific publication and oral communication at conferences and in multinational laboratories—it is almost always the *only* language of such

communication. There are many ways to illustrate this, from grabbing your nearest scientist and simply inquiring to perusing the shelves of scientific journals in any technical library, but the quickest way of surveying the extent of the transformation is with numbers. As in the graph presented in the introduction, the evidence of the past half century is unequivocal. If one counts the cover-to-cover translations of Soviet journals as "English" articles—and one really should, since this was how most Soviet science was consumed abroad—then already by 1969 fully 81% of the physics literature appeared in English. More conservatively, *Chemical Abstracts* recorded in 1980 that 64.7% of the articles it abstracted appeared originally in English, 17.8% in Russian, and 5.2% in Japanese, followed by smaller numbers in German and French (with Polish next in line, at 1.1%), a dramatic transformation from the triumvirate that had opened the twentieth century. Between 1980 and 1996 German dropped from 2.5% to 1.2% across all the natural sciences and Russian equivalently moved from 10.8% to 2.1%; English, on the other hand, had jumped from 74.6% to 90.7%.[3] That data, however, does not fully take into account the consequences of the collapse of the Soviet Union or the globalization of China and India. It is hard to measure the total output now, but in elite journals across the natural sciences, no matter the country of origin, well over 98% of publication—a sum that has, recall, been steadily increasing over time—is in English.[4] There is an absolute flood of natural knowledge being produced in a language once confined to the southern part of one particular island in the North Sea.

It is not just a question of *how much* English, but also *what kind* of English we are talking about. English, like any other language, shows enormous (and constant) diversification and divergence, differentiated by geography, social class, race, and other factors. These distinctions range not only from the obvious markers of accent or word choice ("flat" vs. "apartment"), but to dramatic rearrangements of syntax. That is, the tension we have explored between opting for "identity" (expressing yourself in the idiom most comfortable to you) and "communication" (attempting to reach the broadest audience possible) remains an issue for English speakers even when talking to others who speak ostensibly "the same" language.[5] If you believe that all "English" speakers are mutually intelligible, you need to get out more.

Nonetheless, there is a "standard" English that facilitates communication around the world, although it is not regulated by any official state body as in the case of French or Modern Hebrew, and the English spoken and written by scientists is an even more rigorously standardized and specialized variant.[6] The peculiar features of international scientific English, the particular history of its emergence, and the impact of its growth upon the other dominant languages of science, are the subjects of this chapter, concluding the history of scientific languages we have traced through the centuries. It seems that the oscillation between communication and identity seems to have settled, for the present, very definitively upon the "communication" side of the spectrum. English's rise has received its greatest push not from native speakers, but from *non*-native Anglophones (the majority of scientists and engineers in the world) using the language to reach the broadest audience. This has happened largely because English has come to be seen—rather surprisingly, given its history—as a "neutral" international mode of communication, whereas using French or Russian or Japanese is interpreted as a gesture directed at domestic audiences. This perception of neutrality has been the engine enabling English's omnipresence in international science.

How Widespread Will English Become?

The development of English—from the arrival of Angles and Saxons to the British Isles, the intermixing of Scandinavian influences due to Viking invasions, the Norman conquest of 1066 and the grafting of French forms onto the dominant Anglo-Saxon, the constant presence of Latin (from Roman centurions to medieval monks), down to the flourishing of Geoffrey Chaucer's Middle English and William Shakespeare's Modern English—has been extensively studied, and this is not the place to rehearse well-worn milestones.[7] Although one might presume that the position of English in the world today is most heavily indebted to imperial expansion, it is rather the case, as linguist Robert Kaplan has observed, that "the spread of English is a relatively modern phenomenon;[. . .] most of the spread has occurred since the end of World War II."[8] The rise of English not only in the sciences but in other areas actually postdates the high-water mark of the British Empire in the eighteenth and nineteenth centuries.

For most of the period when the speaker base of English was centered in Britain, the prospects for its diffusion were not particularly rosy. In 1582, Richard Mulcaster, often considered the founder of English lexicography, sadly noted that "[t]he English tongue is of small reach, stretching no further than this island of ours, nay not there over all."[9] A century later, after Britain's first wave of overseas colonization, there were only an estimated eight million speakers of the language

worldwide.[10] Foreign correspondence, both mercantile and diplomatic, took place in the dominant vehicular languages of the early modern age: Latin, French, and Dutch. As late as 1714, when the posthumous edition of French linguist Giovanni Veneroni's dictionary of the chief languages of Europe was published, English was not considered important enough to include beside French, German, Italian, and Latin.[11] Later, provinciality was displaced by an abiding certainty that French-speakers and German-speakers (let alone the rest of the planet) would not accede calmly to the enormous advantage the global spread of English would give to British and American national interests.[12]

Geopolitics was one strike against English's dominance; another, perceived by many to be much more serious, was the sheer difficulty of the language. English was too hard to be global. In 1886, Scottish phonetics pioneer Alexander Melville Bell—whose much more famous son and namesake is credited with the invention of the telephone—published an ambitious pamphlet entitled *World-English*. Writing in the shadow of ever-growing Volapük, he was mostly optimistic: "No language could be invented for International use that would surpass English, in grammatical simplicity, and in general fitness to become the tongue of the World. The only drawback to extension of English has been its difficult and unsystematic spelling."[13] Orthographic reform could remove the final roadblock—although the sheer bizarreness of his proposed new letters to represent specific sounds (which I would love to reproduce but am prevented by typographic constraints) may give the modern reader pause. (It is striking, in fact, how rarely spelling comes up as an obstacle in contemporary discussions of scientific English, probably largely because the lexicon is so circumscribed for each subdiscipline.)

The much more common diagnosis of English's difficulty stressed the sheer variety of words covering similar notions, and the proliferation of grammatical exceptions that often obscured what boosters saw as the tongue's essential simplicity. The most prominent critique in this direction was C. K. Ogden and I. A. Richards's Basic English. According to Richards, among the leading literary critics of his generation, the idea occurred to Ogden while the two were writing their book on semantics, *The Meaning of Meaning*.[14] While exploring definitions of various abstract terms, Ogden was struck by "the fact that whatever you are defining, certain words keep coming back into your definitions. Define them, and with them you could define anything."[15] The solution to a universal language might be to preserve the simple grammar

of English—no gender, limited agreement, fixed word order—and cap the vocabulary.

Basic English, Ogden and Richards would insist, was nothing more than English with fewer words, 850 to be exact: 600 names of things, 150 names of qualities, and 100 "operations," a catch-all category that lumped verbs together with prepositions.[16] Basic English, Ogden proclaimed, "is an English in which 850 words do all the work of 20,000, and has been formed by taking out everything which is not necessary to the sense. *Disembark*, for example, is broken up into *get off a ship*. I *am able* takes the place of I *can*; *shape* is covered by the more general word *form*; and *difficult* by the use of *hard*."[17] Richards—the St. Paul for Ogden's language—held that 850 was the perfect number: "It would be easy to cut Basic English down to 500 words, but then it would depart from Standard Usage and at the same time the strain of making the limited language cover the needs of its users would increase prohibitively."[18] Perhaps, but is "umbrella" essential? Is "dance" superfluous? Ogden and Richards were inflexible about the core vocabulary, but they admitted that specialist activities—importantly including science—demanded supplemental vocabularies, which could be added on to the basic word list or simply defined upon their first use in terms of the original 850.[19]

According to its advocates, Basic English solved every difficulty that beset English. First, it was "not greatly different from ordinary standard English."[20] This meant that, unlike a pidgin or simplified language, there was nothing to unlearn in moving from Basic to Standard English—the former was a proper subset of the latter; nothing that was grammatical in the first would be unintelligible to native speakers. Second, by quickly enabling students to maneuver with the language, it would lessen feelings of "intellectual, technological, or other domination" by English speakers.[21] That said, in 1943 the British War Cabinet began active promotion of Basic, which they hoped would prevent the disintegration of the language into pidgins and dialects as the British Empire continued to occupy disparate regions of the world. Basic English, under the active personal promotion of Richards, even had a distinguished career in Republican China before the Japanese invasion at the start of World War II.[22]

Basic English did not lack for contemporary critics. One of the most forceful arguments came from Lancelot Hogben—British biologist, statistician, and science popularizer with a knack for languages. "With due recognition of [Ogden's] unique achievement," he wrote, "it is there-

fore important to state charitably at the outset why Basic was bogus."[23] The answer was what he called "mnemonic load." While Ogden and Richards claimed they could minimize learning difficulties by reducing vocabulary, was replacing "belittle" with "make light" and "manifest" with "come to be" really a savings? For a word, one must now memorize a compound phrase. The real work lay in the metaphors behind the words, a point essentially conceded by Richards, who noted that "it must not for a moment be supposed that Basic leaves it to the learner to invent and experiment with these metaphors at random. The greatest part of the labour of producing Basic did in fact go to the thorough inventory of these metaphors."[24] More sniping followed: Basic sounded wooden; it functioned as a pidgin; it was helpful for reading but not writing or speaking; it did nothing for pronunciation; and it merely delayed the inevitable need to learn English.[25] If English was inhibited because it was too hard, too verbose, too difficult to spell—then Basic English would not help.

It was not obvious even in the wake of World War II that English would take over the way it has. In a history of "scientific English" penned in 1947, a curmudgeonly author anticipated the continuation of the triumvirate: "Thus it is that every scholar today is trilingual, perhaps lamely so but still struggling valiantly toward that end. Three instead of one linguae francae for science are a burden."[26] And even those who recognized that English was on the rise—and a cursory examination of abstract journals would tell any scientist that, as of September 1949, 57% of all scientific articles were published in English—there were still fears that "Russian, Chinese, or Urdu" would eventually supplant this dominance.[27] With the benefit of hindsight, we know this did not happen. Not by a long shot.

When Did English Come to Seem Inevitable?

It is broadly assumed that the greatest hostility to the omnipresence of English is based in Paris, a reasonable inference based on the visibility of excoriations of English by politicians and intellectuals in the Fifth Republic. Yet even as far back as 1982, the dominant attitude in French scientific periodicals toward the growth of English publishing was resignation. "Despite the fact that French is still the language of scientific work in West Africa, in the countries of the Maghreb, in Quebec, and in certain francophone European countries," noted a special commission of the *Comptes rendus*, the journal of the storied Académie

des Sciences, "English is today the international language of science; it could become its sole language very soon."*[28] The commission wondered then—and some French commentators have continued to ponder today—whether there was even any point in maintaining French-language scientific journals, dressing up as serious research what might be better understood as "popularization."[29] When did such views become reasonable to their proponents? When and why, that is, did *non*-native speakers of English begin to see the position of English in the sciences as a fait accompli?

One dominant factor is the sheer size of the scientific vocabulary in English. There are more words in English dedicated to the various sciences than for any other function, as a casual glimpse on almost any page of a reasonable dictionary will make abundantly plain.[30] (There are also more scientific words in English that have at least partly Ancient Greek roots than there are words in Ancient Greek.[31]) The size of the vocabulary not only indicates that it is possible to conduct research in any science in English; with each word that is developed for English alone, it becomes harder to repeat the Russians' accomplishment from chapter 3 and engineer a scientific language in, say, Tagalog or Swahili or Malay. One would need to develop a standard term for every scientific notion, publicize it, and get it into use. The cost of this, as well as developing the full complement of publishing houses, is overwhelming, even increasingly for languages like German, which have a healthy scientific vocabulary of their own.[32]

For most scientists, the sharpest evidence of Anglification has been in the contents of scientific journals, the main outlet by which findings about the natural world are disseminated. The pattern has become so routine as to be almost cliché: first, a periodical publishes only in a particular ethnic language (French, German, Italian); then, it permits publication in that language and also a foreign tongue, always including English but sometimes also others; finally, the journal excludes all other languages but English and becomes purely Anglophone, regardless of whether it is published in Milan, or Marseilles, or Mainz, or Mexico City. As one (English-speaking) chemist put it: "[O]nce an editorial committee decides to allow the use of English in the pages of its jour-

*"Bien que la français soit encore la langue de travail des scientifiques en Afrique occidentale, dans les pays du Maghreb, au Québec et dans certains pays européens francophones, l'anglais est dès aujourd'hui la langue internationale de la science; elle pourrait devenir très prochainement sa langue unique."

nal, it finds that it has invited a cuckoo into its nest that pushes the native fledglings aside."[33] Foreign publishers, adjusting to copyediting and production in English, have incurred higher costs in hiring editors with the obligatory native or near-native English skills.[34] Often, but not always, the name of the journal changes as well, the bland English moniker hiding any trace of the national origin of the periodical. A scattershot survey will suffice: *Die Heidelberger Beiträge zur Mineralogie und Petrographie*, founded in 1947, became *Contributions to Mineralogy and Petrology* in 1966; *Mineralogische Mittheilungen*, founded in 1871, became *Mineralogy and Petrology* in 1987; *Zeitschrift für Tierpsychologie*, which published 100% of its articles in German in 1950 (although English, French, and Italian were acceptable), began to shift to English already in 1955, and changed its name to *Ethology* in January 1986; the storied *Annales de l'Insitut Pasteur* became *Research in Immunology* in 1989; the Mexican *Archivos de Investigación Médica* transitioned gradually in the 1980s into the *Archives of Medical Research*; the *Archiv für Kreislaufforschung* is now *Basic Research in Cardiology*; the *Zeitschrift für Kinderheilkunde* is now the *European Journal of Pediatrics*; *Gastroenterologia* became *Digestion*; and the official organ of the Japanese Society of Plant Physiologists is called *Plant and Cell Physiology*.[35]

Simply relating a list of titles does not, however, give a sense of how this transformation was experienced by the non-Anglophone contributors to these journals. An instructive case in point is *Psychologische Forschung*, founded in 1921 by Kurt Koffka and several other giants of German psychology, which rechristened itself *Psychological Research* in 1974, adding the subtitle "An International Journal of Perception, Learning, and Communication." The transition to a fully English journal had been in the cards for a while. In 1971–1972, the journal published 24 articles, 13 of which were by German-speaking authors, yet 18 of the articles appeared in English and only six in German. Only eight of the English articles displayed German abstracts. After the language change, German abstracts atrophied. Examining the "Instructions for Authors" published in the journal's paratext gives some indication of why. In *Psychologische Forschung*, potential contributors were informed, in German, that "Contributions will be accepted in German, English and French. It is requested that *manuscripts* be composed *in English as far as possible*"* (emphasis in original); but in *Psychological Research*

*"Es werden Beiträge in deutscher, englischer und französischer Sprache angenommen. Es wird gebeten, die *Manuskripte möglichst in Englisch* abzufassen."

the English-language equivalent declared: "*Papers should be preferably written in English*" and also that "[e]ach paper should be preceded by a *summary* of the main points. . . . Papers in French and German should also have the title and summary in English." Werner Traxel, an irate Germanophone psychologist, wrote to the publisher in April 1975 and asked whether, as the instructions implied, the journal would still accept German articles, and if so whether they would facilitate a translation into English. An editor responded that English articles were strongly encouraged, and that if Traxel felt uncomfortable in the language "[p]erhaps you have an English-speaking colleague who can be helpful to you in the translation. Insofar as this is not the case, in exceptional cases there is the possibility of sending the manuscript to an editor of the journal who lives in Germany . . . to proofread the English."* [36] A linguistic tradition in psychology was at an end, and no resources were provided to guide stragglers into the new standardized scientific communication.

Standards demand conformity. Just as there had earlier been manual upon manual to teach Anglophones how to read chemical German or technical Russian, new handbooks instructed scientists in "scientific English," all published, *natürlich*, in English.[37] That is, if you wanted, like most researchers in Helsinki, to compose your articles in English instead of having them translated (expensively) from Finnish, you had to be fluent enough in English to fully comprehend the guide that would help you accomplish your goal.[38] The format of scientific articles had, over the past two centuries, become increasingly regularized until it reached its homogeneous postwar rubric of Introduction, Methods, Results, and Discussion (IMRAD); this much was obvious.[39] Less apparent but no less real was that the *English* too had compressed to very limited variation. Scientific English, even more so than scientific French and German, was characterized by a uniformity of style: "relatively short, syntactically simple sentences containing complex noun phrases with multiple modification, verbs in the passive voice, noun strings, technical abbreviations, quantitative expressions and equations, and citational traces."[40] The standard English of scientific prose, distinct from the "standard English" of Hollywood and the financial

*"Vielleicht haben Sie einen englischsprachigen Kollegen, der Ihnen bei der Übersetzung behilflich sein kann. Sofern dies nicht der Fall ist, besteht in Ausnahmefällen die Möglichkeit, das Manuskript an einen in Deutschland lebenden Herausgeber der Zeitschrift . . . zur Überprüfung des Englischen zu senden."

press, amounted to a new dialect for nonnative speakers (and for native speakers too, as anyone who has attempted to write scientific prose has learned).

Alongside the hegemony of English in written science, its prominence in spoken science as, in most instances, the only language of international scientific conferences, is just as striking, and substantially more burdensome. Translation is expensive, and so only manageable at selected large meetings; most scientific gatherings are of smaller scale and take place without the benefit of professional interpreters.[41] This difficulty is exacerbated by the fact that many native speakers of English, unaware of the height of the language barrier or its radical asymmetry, often make little to no accommodation to the linguistic capacities of their audience. Although most international scientists consistently self-identify English as their best foreign language, multiple studies indicate that nonnative speakers are "*handicapé par la langue*" in oral communication.[42]

Science policy makers in traditionally strong scientific countries have been making significant adjustments to this emergent Anglophone world for decades. Japanese researchers functioned since the mid-nineteenth century with the knowledge that they would need some vehicular language besides Japanese if they wanted to be understood abroad, a need also reflected in a tradition of publication in European languages as well as Japanese (especially for graphs and figures). Now English is the chief language deployed. RIKEN, Japan's premier research institute, reported the publication of just under 2,000 research reports in English, but only 174 in Japanese in 2005, and even domestic scientific gatherings are using English.[43]

Anglophonia is starting ever earlier, saturating education at lower levels. The Jacobs University in Bremen, Germany, offers all of its instruction in English. In a newspaper interview, an undergraduate biology student who studied *E. coli* was excited by this development. "I find it convenient that there is a single leading scientific language," he told reporters. "Only when I tell my grandparents about my studies does it sometimes become complicated. Then I have to translate twice—first from scientific language into lay language, and then again into German."* In fact, "English was one of the chief reasons for me to begin my studies at Jacobs University. Because I definitely want to go into research, and as we all know everything there runs in English."*[44] In about half of the international bachelors programs for the German Academic Exchange Service (DAAD), education is exclusively in English, while 460 of 640 International Masters Programs in Germany use English as the exclusive language, up from 250 in 2007. Advanced science students are obligated to use English-language textbooks regardless of the language of instruction.[45] Already in the 1980s, eight German universities permitted scholars to submit dissertations in English, and this is now essentially universal in the natural sciences and increasingly common in the social sciences and humanities.[46] As a consequence, as a manifesto of academics declared in 2005, "the use of the English language conveys the impression that in Germany one can no longer formulate and express ideas as before. Students and scientists would prefer to study, research, and teach in the Anglo-American original than in such a country."†[47]

As a final illustration of the ubiquity of English, consider the stories of an admittedly biased population: Nobel laureates in Chemistry in the twenty years since the collapse of the Soviet Union. Between 1992 and 2011 there were 45 laureates, and of course this limited sample is profoundly unrepresentative. In fact, they were awarded the prize *because* their work was deemed exceptional, and many of them led unusual careers. It is important to remember that these scientists were awarded the Nobel for work performed many years, sometimes decades, earlier, often during the height of the Cold War. The English in their backgrounds illustrates how long ago Anglification became a dominant feature of the landscape of chemistry. There is no reason to expect other sciences to be significantly different; in the case of physics, the effect is likely even more pronounced.

What does this sample tell us? Of the 45 laureates, 19 (42%) were not native speakers of English, an indication of the enormous resources poured into science by the United Kingdom but especially the United

*"Ich finde es angenehm, dass es eine einzige führende Wissenschaftssprache gibt. [. . .] Nur wenn ich meinen Großeltern von meinem Studium erzähle, wird es manchmal kompliziert. Dann muss ich zwei Mal übersetzen—erst von der Wissenschafts- in die Laiensprache und dann noch ins Deutsche."

*"Für mich war das Englische einer der Hauptgründe, an der Jacobs University mein Studium zu beginnen. Denn ich will unbedingt in die Forschung, und da läuft nun mal alles auf Englisch."

†"vermittelt der Gebrauch der englischen Sprache den Eindruck, man könnte in Deutschland neue Ideen nicht mehr als erste formulieren und aussprechen. Ein solches Land wird für Studenten und Wissenschaftler studieren, forschen und lehren daher lieber gleich beim angloamerikanischen Original."

States. (The most pronounced minority is women: only one in the entire set.) Only three of these chemists, according to their official autobiographies, passed their entire career without ever having studied or worked in an Anglophone context. All of them knew English in order to keep up with the literature, but this small number indicates that by far the most common way of securing a command of the language was to spend time in an environment entirely surrounded by it. World War II marked most of these laureates, many of whom were refugees, the children of refugees, or otherwise affected by the conflict. With that, the commonalities end; each chemist had an idiosyncratic path to science.

A surprising number brought up language in their autobiographies. Although most of these were originally written in English, there is an undertone of other languages studied with hopes of breaking into science. For example, Mario J. Molina, born in Mexico City in 1943 and laureate in 1995, "was sent to a boarding school in Switzerland when I was 11 years old, on the assumption that German was an important language for a prospective chemist to learn."[48] German was studied by several, and yet almost none who were not native speakers of the language published in it. On the other hand, English is everywhere. As one of the three who had no direct Anglophone exposure, Jens Skou—born in Denmark in 1918, laureate in 1997, and a resistance fighter against Hitler's occupation of his homeland during the war—noted that his 1954 dissertation was published in Danish "and written up in 6 papers published in English" immediately afterward.[49] Publishing in English seems to have been most crucial (and challenging) for the Japanese laureates. Koichi Tanaka, born in 1959 and co-recipient of the 2002 prize, at first studied German in university, although he lamented his poor grades in the subject. The major transition in his career came in September 1987, at the Second Japan-China Joint Symposium on Mass Spectrometry in Takarazuka, Japan, when "we announced our results in English for the first time." That is, even though this was a meeting primarily for Chinese and Japanese, English was the crucial language. "There is a double significance here," he continued, "in that not only were the research results written in English, I actually presented the results in English for the first time. Although my English was far from good, my meaning was well enough understood by Professor [Robert] Cotter [of Johns Hopkins University] for him to make the results known around the world."[50] A similar story, characterized by diligent study of the language, was expressed by El-Ichi Negishi, born in Japanese-occupied China in 1935 and laureate in 2010, whose English was further strengthened by obligatory classes associated with his Fulbright award at the University of Pennsylvania.[51] Perhaps the most poignant, however, were the recollections of Ahmed H. Zewail, born in 1946 in Damanhur, Egypt, who was the sole recipient of the Nobel in 1999. He studied in the United States and now works there, but his arrival was rough:

> I had the feeling of being thrown into an ocean. The ocean was full of knowledge, culture, and opportunities, and the choice was clear: I could either learn to swim or sink. The culture was foreign, the language was difficult, but my hopes were high. I did not speak or write English fluently, and I did not know much about western culture in general, or American culture in particular.[52]

The Nobel population, though not typical, is indicative of some major trends. As the Nobel Prizes have been awarded since 1901 by the Swedish Academy of Sciences, the history of the science prizes can tell us a lot about how Swedish science—that is, science in a small, wealthy, geopolitically peripheral nation—fits into the global context. Until the end of World War II, the overwhelming tendency was to award prizes to German scientists. On the one hand, this was a reflection of the tremendous ferment in German science in that period. On the other, it is also an indication of educational patterns: Swedish scientists were often educated in Germany and German was their most comfortable vehicular language. They therefore read German publications and nominations with greater ease. The same characteristics of both quality and concomitant linguistic familiarity can be read in the dominance of Anglophone publications and scholars after the Second World War. In the Nobel population, the point of transition seems to be 1920; scientists born after that date lived in an Anglophone world.[53] When this pattern is broken, there is usually an interesting story to be found. For example, Soviet chemist Nikolai Semenov won the Chemistry Nobel in 1956 largely as the result of persistent lobbying by Lars Gunnar Sillén, professor of inorganic chemistry at the Royal Swedish Institute of Technology in Stockholm, who happened to know Russian and was committed to improving Swedish-Soviet relations.[54] Without an inside advocate possessing an unusual linguistic profile, the message is quite clear: if you aim for the Prize, aim in English.

Why Did This Happen?

As with any historical change on such a broad scale, involving many thousands of scientists spanning the entire globe across more than a century, there were many causes of this compression to a single language. First, the triumvirate had to be displaced before English could break away from French and German. The initial destabilizing impulse came with the rise of nationalist ambitions from large scientific cohorts such as the Russophone one, which challenged the tight strictures around three dominant languages, but this was overshadowed by the refusal of the largest and richest Anglophone population, that in the United States of America, to continue learning foreign languages. These factors were supplemented by geopolitical developments by which American science was lifted with American power, and the English language alongside both.

English itself was not responsible—that is, English does not possess specific qualities that make it particularly well suited for scientific research. Most linguists today would shudder at the notion that any language is intrinsically suited for, say, chemistry, not least because languages themselves are subject to constant modifications and interactions. Yet repeatedly one finds claims that this must be what lies behind English's victory. For example, Max Talmey, the prime advocate of Ido in interwar America and a native speaker of German, considered English "far richer, far more expressive than any other language. Far more often than with any other tongue one meets, in a comparison pertaining to expressiveness, with concepts each expressible in English by a single word and only by a circumlocution in any other language," while even a French scholar considered English "more malleable, more plastic than French as far as being a vehicular language."* [55] Other paeans to its simplicity and "masculinity" can also be set aside.[56]

More powerful than any intrinsic linguistic advantage to English was a definite *political* backlash against German in the wake of National Socialist brutality. The reaction against German in the United States happened earlier, with the nihilistic enthusiasm of anti-Teutonic sentiment uncorked by the Great War; to a lesser degree, other nations dismantled their German educational structures in the late 1940s. Even Germanophilic Sweden, neutral in the global conflagration, replaced German with English as the first foreign language taught to children, beginning

* "plus malléable, plus plastique que le français en tant que langue véhiculaire."

in their fifth year of school, in 1947. Two years later, students destined for higher education could begin to study a second foreign language, typically German, but those headed for practical training only learned English. Similar patterns, ramified across the globe, wrought enormous damage on knowledge of German.[57] Even Indonesia had banned German instruction in 1940, and when it was reintroduced to the schools in 1945 it was met with remarkable lack of enthusiasm on the part of both students and teachers.[58]

While German as a global language of scholarship suffered because of the actions of Germanophone political leaders, to a limited degree English benefited from active promotion by Anglophone governments, especially the United States. On 11 June 1965, American President Lyndon B. Johnson declared that the promotion of English was now "a major policy," and the Peace Corps, the US Agency for International Development, and other organizations encouraged study of the language.[59] Likewise, the American (and British and Canadian) leadership of the North Atlantic Treaty Organization (NATO), two out of five Anglophone seats on the United Nations Security Council, and American sponsorship of the International Monetary Fund (IMF) surely did not hurt the status of English as an international language.[60] Although, as of 1 January 1975, English was the sole official language in only 21 countries, it was recognized alongside a local language in 11 more and grew increasingly popular in international organizations, becoming by 2004 the official language of 85% of the 12,500 such organizations worldwide. (French came second at 49%.)[61] Yet the Anglification of the sciences *preceded* many of these policy measures, and much of the enthusiasm for the language stems not from top-down political promotion, but from the ground up.

These trends notwithstanding, there was a good deal of pessimism in the 1960s, especially in the United Kingdom, about the future of English as a language of science. Such gloominess seems like lunacy in the face of that curve of ever-increasing English abstracts that we saw in the introduction, but a closer look reveals a plateau in the 1960s combined with an uptick in Japanese and Russian—not just foreign tongues, but written in impenetrable scripts to boot! As one study from 1962, bemoaning the slippage of English, put it: "It seems wise to assume that in the long run the number of significant contributions to scientific knowledge by different countries will be roughly proportional to their populations, and that except where populations are very small contributions will normally be published in native languages."[62] In addition,

there were certainly plenty of predictions, even into the late 1970s, that decolonization would produce a new international Babel that would have made the inferno of the nineteenth-century age of nationalism seem like a brush fire.[63] Given the global reach of the British Empire, hostility to English was particularly noticeable.[64]

One of the most curious features of the rise of English is the fact that political resistance from rapidly decolonizing nations did not provide effective resistence either in diplomacy or in scholarship. Decolonization did little to staunch the spread of Anglophonia, often because of the unavoidable necessity of some vehicular or auxiliary language. For example, at the 1955 Bandung Conference, where nonaligned nations proclaimed their autonomy both from former colonial masters and the growing US-Soviet Cold War, participants settled, after intense and often heated discussion, on one official language: English.[65] Meanwhile, developing nations in what was once called the "Third World" have repeatedly opted for English. Ethiopia, for example, never colonized by a European power, added English as an official language, signaling a much broader trend. Students from most decolonizing countries, especially in the sciences, often selected their destination of foreign study precisely to gain fluency in English. The United States was particularly desirable, as students flowed across the network established by Cold War foreign policy. Seven thousand foreign students studied in the United States in 1943, growing to 26,000 in 1949 and 140,000 in 1971, an expensive enterprise funded in part by the United States government but increasingly by grants from home countries.[66]

The crucial shift was the transition from a triumvirate that valued, at least in a limited way, the expression of identity within science, to an overwhelming emphasis on communication and thus a single vehicular language. The very same arguments that had been pooh-poohed when voiced by Esperantists and Idists at the dawn of the twentieth century came to be unquestioned axioms by century's end. Most sociologists and applied linguists who have examined the hegemony of scientific English have pointed to English's ubiquity as the almost accidental outcome of computerized reference tools and the inexorable and omnipresent gravitational pull generated by the wealth and scientific prominence of the United States.[67] Early computerized databases privileged English; it was estimated in 1986 that fully 85% of the information available in worldwide networks was already in English.[68] Database followed database, and the advent of hyperinfluential metrics such as the Science Citation Index and "impact factors" only increased the

first-mover advantage that had accrued to American indices. Publishing in English placed the lowest barriers toward making one's work "detectable" to researchers.[69]

The jig was therefore already up when the second most popular—but grossly diminished—scientific language faced a terminal crisis on Christmas Day, 1991: the dissolution of the Soviet Union. Russian had been losing status in the sweepstakes of scientific languages since the early 1970s upon the dramatic international success of American cover-to-cover translation efforts. It had until then been boosted as a scientific language by precisely the same kind of graduate-study and postdoctoral flows from the Third World that were so significant for English, but the numbers—7,600 students from Latin America at the height in 1985—were a drop in the bucket compared with those headed to the United States, and the bucket had developed a serious hole in the bottom: Eastern Europe, which began to calve off the Soviet Bloc with rapidity as that decade reached its end.[70] Russian was stripped of its special status everywhere but Romania—which had abandoned obligatory Russian decades earlier—prompting a deluge of students into German and English. (German was a surprise beneficiary of the decline of Russian from the Baltic to the Balkans.)[71] Although post-Soviet researchers expressed a reluctance to publish in English for several years after the extent of the damage was made clear, the realities of the new vehicular language set in. In 1991, the Soviet Academy of Sciences set up the Nauka/Interperiodica International Publishing House in cooperation with an American firm. Their mission: to make English versions of 88 academic journals, translated by experts and edited by Americans. Cover-to-cover had ceased to be a stopgap, catch-up scramble by American scientists to handle Russian work, and was now the official outlet of Russian scientists trying to be heard overseas.[72] The mutable evolving story of scientific languages seemed to have reached equilibrium, or stasis.

Is This a Good Thing?

The answer, of course, depends on your view of science and your attitude toward English. Aside from those native Anglophones who breathe a sigh of relief at no longer having to struggle through manuals of scientific French, the most salient argument in favor of the developments described in this chapter has been that English is "neutral." English is a rather funny language in many respects. It has proven enormously pliant over the centuries, absorbing words, idioms, even syn-

tax from dozens of different languages. It has no centralized academy to regulate usage. It does not even have a single dominant country, for surely the burly United States is at least strongly counterbalanced by the United Kingdom, not to mention India, which possibly has more speakers of the language than both combined. As Sabine Skudlik, one of the leading scholars of English as a scientific language, has noted: "This is the really new thing, the essential marker of modern Anglophony in science: that it not only bridges the differences of languages, but neutralizes all separating differences, whether of a linguistic or a more generally cultural kind."* [73]

English—whose dominance as a language of science we have seen to be intimately linked to geopolitics, personal preferences, economic pressures, and a host of contingent twists and turns—is understood as neutral ground, even by critics of the virtual disappearance of German, French, Russian, and Japanese.[74] How is it possible, even reasonable, to come to this conclusion? Perhaps it was not so much that English was seen as neutral and therefore appropriate for scientific interchange, but rather that the association with science, long famed for objectivity and impartiality, endowed Anglophony with neutrality, American hegemony trailing behind an Erlenmeyer flask. Any aura of neutrality has been enabled by native speakers of other languages—especially so-called "minor languages," like Dutch or Danish—who prefer it to German or French. (As is easy to observe, English benefits greatly from being "not French" or "not Russian.") In fact, these days, publishing science *not* in English is seen as marked, and is almost always done only by a native speaker of the language in question; if you see physics published in Russian, odds are that a Russian is the author.[75] Yet evidence that English is not neutral is remarkably easy to find. The most obvious asymmetry is that a certain segment of the community learns the language effortlessly as children; the rest—the majority—struggle through years of education. Their goal is not just to be able to muddle through an English article, dictionary in hand, to extract a general sense, but to acquit themselves orally under the intense pressure of hostile interrogation at a conference. Scientists are typically not gentle in their probing

*"Das ist das eigentlich neue, das wesentliche Kennzeichen der modernen Anglophonie in der Wissenschaft: daß sie nicht nur Sprachunterschiede überbrückt, sondern alle trennenden Verschiedenheiten, ob sprachlicher oder allgemein kultureller Art, neutralisiert."

of their colleagues, and a failure of fluency can be a fatal handicap for one's theories, or one's career.

"Struggle" is the correct word for many scientists' encounters with learning English. French and German are both closely related to English—the former contributing to the shaping of Middle English after the Norman Conquest, and the latter by virtue of kinship within the Germanic language family. Yet native-speaking scientists of these two languages express significant frustration with even the reduced structures of scientific English. Germans seem to Americans to have an amazing command of the English language, but that is partially a product of selection bias: the conversations you remember are the ones that you actually manage to have. In a 1995 survey of scientists at the University of Duisburg in northwestern Germany, 25% reported trouble reading English science, 38% had problems with speech, and 57% were challenged by writing.[76] This among a set of professionals who have the broadest exposure to the language and in a country where English study is obligatory. Werner Traxel, who protested the linguistic overhaul of *Psychological Research*, attributed the flaw to the English language itself: "Above all however English is not only an extremely flexible and nuance-rich language, but also one that, for the most part, cannot be described with fixed rules (in contrast to the Romance languages). Thus it gives us the impression that it is relatively imprecise, and indeed constructions that go against the logic of the language appear not infrequently in the specialist terminology in English."* [77] But just as English is not uniquely suited to science, it cannot be uniquely *ill*-suited either. A response to Traxel noted an interesting ambiguity about provincialism and internationality. On the one hand, knowing only one language can be seen as provincial, and insisting on diversity can enhance international exchange; on the other, if that one language is English, resisting it might be a knee-jerk provincial response. In short, Traxel had just better get over it.[78]

Not that he had a choice: English had become a seemingly permanent fixture of the intellectual landscape. The efficiency gains seem to

*"Vor allem aber ist das Englische nicht nur eine überaus flexible und nuancenreiche, sondern auch eine weitgehend nicht in feste Regeln faßbare Sprache (im Unterschied etwa zu romanischen Sprachen). Daher erscheint es uns auch leicht als relativ unpräzise, und in der Tat sind sprachlogische Fehlbildungen in der englischen Fachterminologie nicht selten."

have been tremendous, since essentially all elite natural science now appeared in one language without the tedious process of translating. Of course, the current state of affairs seems more efficient only to the native speakers of English; the gains have come at the cost of *everyone else* learning fluent English. Weighing the costs and benefits is a tricky affair, but it appears that the bump under the rug has only been moved around rather than smoothed out. The flip-side to all this English learning, adding insult to injury for many foreign scientists, is that most English-native scientists have given up all pretense of learning foreign languages.[79] Beginning in the 1960s, foreign-language requirements for graduate study in various sciences began to be eliminated—initially dropping from two to one, and then by the 1980s from one to zero.[80] This change confronts us with a chicken-egg dilemma in terms of causation. The absence of a language requirement obviously meant that ever fewer students would be equipped to consult foreign scientific literature, tilting the Anglophones ever more strongly into English; on the other hand, the requirements were eliminated in large part because they were no longer seen as necessary. Whichever way you understand it, there was no arguing with the consequences. "Those who speak English may get the impression of being—more or less—at home everywhere," wrote one rare Anglophone observer who noticed the asymmetry. "This helps to be quicker, more mobile and more efficient, which corresponds to modern ideals of life and work. To superficial observers the whole world seems to be steeped in English. It is an impression which may breed irritation."[81]

Just so. Lingering behind objections to scientific Anglophonia lies a nagging sense of the unfairness of it all. German scientists, to take a prominent example, have to make the difficult choice between identity and communication, between supporting journals and educational institutions in their native language or disseminating cutting-edge research to the broadest-possible readership. Anglophones don't; there is no dilemma, because identity and communication are the same.[82] The inequities extend beyond psychological comfort, because native speakers of English, by virtue of not having to spend time learning languages, have more time to study science, research, and publish. As a result, native speakers of English are overrepresented in the scholarly literature. Even though there are more nonnative-Anglophone scientists than vice versa, one study has found that only about 20% of the global quantity of English scientific works are produced by those individuals.[83] One political theorist has even suggested that the unfairness might be moderated by a progressive taxation scheme, whereby Anglophone scientists might pay slightly higher page-costs for their publications, which in turn would be used to subsidize the copyediting of nonnative submissions.[84]

It seems evident that Anglophone hegemony in the sciences would be disadvantageous for some *scientists*, but surely this is simply the luck of the draw. Americans used to be disadvantaged by the German dominance in chemistry, for example. A more abstract but potentially more serious question remains: is the current system bad for *science*? Or for *English*? The questions are related, but the arguments they raise are slightly different, so we will take them in turn.

First, is English bad for science—not because it is English, but because it is a single language? Does science benefit when it is multilingual? The contrary position—that it is simpler to have one vehicular language than to have three, let alone dozens—although ignored when Esperantists proferred it, now seems to hold sway. There are plenty of examples of facts delayed in transit, as when it took the rest of the world several years to catch up to what the Japanese were finding out about the plant hormone gibberellin, simply because the publications were trapped in *kanji* and *katakana*.[85] So maybe everyone wins when communication expands.

Or do they? The earliest losers in the lottery of scientific languages are younger students. Imagine a child in sub-Saharan Africa who is being taught chemistry. In what language is the class? If in a Bantu language, who translated the word for "oxygen"? Such a concept has been around for long enough that it might have filtered down to local languages around the world. But how about more contemporary concepts, like ozone depletion, or the Planck length, or object-centric debugging? Educational research to date indicates that children understand scientific concepts better when presented in their native language, but that requires textbooks and lesson plans in all the world's languages.[86] Those don't exist. The further one advances in science, the greater the scarcity of non-English pedagogical materials. If you want to study topological theory or stereochemistry in college, your English needs to be up to snuff. How many students are lost not because of weak scientific skills, but weak linguistic ones?

In the less mathematical sciences, even professional scientists—those who have already cleared the hurdles of advanced education and who presumably are more than passingly familiar with English texts—sometimes suggest that something has been lost with monolingualism.

All science develops through making connections between seemingly unrelated phenomena, and much of this work begins through linguistic metaphors. "If everyday speech is no longer the source of the specialized languages, the linguistic images will be lacking which are necessary to make something novel vividly understandable," noted one frustrated German scientist. "Since every language affords a different point of view onto reality and offers individual patterns of argumentation, this leads to a spiritual impoverishment if teaching and research are hemmed into English."* [87] This resembles the Whorfian hypothesis—that languages carve up nature, and we all live in different worlds shot through with our native languages—but it is hardly so ambitious. Rather, the claim is that insights come more quickly in words that are more familiar. It is, simply, a plea for identity. One might also anticipate deleterious consequences for public policy. It is challenging enough to persuade politicians to act on scientific, technological, or medical evidence given the paucity of public officials with scientific training and the difficulty of understanding the nuances of the data. Add to this a language barrier, and the situation rapidly worsens.[88] These are problems only for the non-Anglophones, but there are burdens on the other side as well, as native speakers of English are imposed upon to translate or correct their peers' papers, and locked out of private foreign-language conversations between lab-mates and at conferences.

Does the English language itself suffer when, as is currently the case for perhaps the first time in history, nonnative speakers of a living language start to greatly outnumber native speakers? If you wanted to isolate an effect, science would be a good place to look, because it has been Anglophone longer and more completely than any other domain of cultural endeavor. The "English" that is used in scientific communication—particularly in written form, but also quite often in oral interchange—is simplified, reduced, stereotyped to highlight communication and minimize stylistic nuance. German sociologist Wolf Lepenies has called this dialect "Englisch II," which another commentator worries has become nothing more than "a practical, reduced communications code."† [89]

*"Wenn die Quelle für die Fachsprachen nicht mehr die Alltagssprache ist, werden die Sprachbilder fehlen, die nötig sind, um Neues anschaulich begreiflich zu machen. Da jede Sprache einen anderen Blickwinkel auf die Wirklichkeit zulässt und individuelle Argumentationsmuster bietet, läuft es auf eine geistige Verarmung hinaus, wenn Lehre und Forschung auf das Englische eingeengt werden."

†"ein praktischer, reduzierter Kommunkationscode"

Imagine one ironic outcome: To the extent Scientific English resembles Basic English, and Basic English was dreamed up in part to minimize the "pidginization" of English in colonial contexts, Scientific English might itself become the pidgin. "Under certain circumstances English as a scientific language in non-English-speaking countries would degenerate into a cookie-cutter-language," linguist Sabine Skudlik observes, "in cases where constant feedback from mother-tongue speakers is not to be expected. This development would be desirable for nobody."* [90]

Almost certainly true, if the effect is in fact happening. The reader may have noticed that for the last several pages an odd thing has occurred to this manifestly historical book: we seem to have lost the past and moved instead to scientists' and linguists' rampant speculations about the future, ill-disguised as a conversation about the present. There seems no way to talk about Anglophonia in science without willy-nilly drifting into ruminations over where this all might lead. Before fully indulging that impulse, it is important to not lose the central lesson of the journey so far: English has attained its current position owing to a series of historical transformations that it also in turn shaped, exploiting a perception of neutrality that it gained through being distinctly non-neutral in either its British or American guise. There is a circularity to studying language and history together, scrambling our notions of time even in the buttoned-down domain of science. The history of scientific languages ends here, until it no longer does.

*"Unter Umständen würde das Englische als Wissenschaftssprache in den nichtenglischsprachigen Ländern zu einer Schablonensprache verkümmern, falls nicht eine ständige Rückmeldung von Muttersprachlern zu erwarten ist. Diese Entwicklung wäre für niemanden wünschenswert."

CONCLUSION

Babel Beyond

Consider a quotation and a story. The quotation comes from Edward Sapir, one of America's leading linguists before the Second World War. In 1921, in the midst of the wholesale destruction of the teaching of the German language in the United States and an international boycott of scientists from the Central Powers, he wrote:

> A scientific truth is impersonal, in its essence it can be untinctured by the particular linguistic medium in which it finds expression. It can readily deliver its message in Chinese as in English. Nevertheless it must have some expression, and that expression must needs be a linguistic one. Indeed the apprehension of the scientific truth is itself a linguistic process, for thought is nothing but language denuded of its outward garb. The proper medium of scientific expression is therefore a generalized language that may be defined as a symbolic algebra of which all known languages are translations. One can adequately translate scientific literature because the original scientific expression is itself a translation.[1]

The historical record shows that the actual state of affairs is and has been—to say the least—more complicated. While it might in principle be the case that the same scientific truths hold no matter which language they are expressed in, as a matter of daily experience the choice of a *specific* language has had enormous bearing on the capacity of scientific messages to be "readily delivered." The friction of translation between Russian and German powered the priority dispute over the periodic system of chemical elements, for example, and replicating Lavoisier's French nomenclature proved problematic both in Swedish and in Russian, not to mention Ido and Esperanto. Sapir also put forward a second claim, about a metalanguage of scientific truth, which brings us to the story.

In 1957, H. Beam Piper published "Omnilingual" as one of a collection of tales from *Astounding Science Fiction*. In view of the Cold War crisis of scientific language imposed by the deluge of scientific Russian pouring into the United States—which prompted new courses in recently established Slavic departments, witnessed the origins of Machine Translation, and finally settled into a steady, and gigantic, cover-to-cover translation industry—Piper's imaginary voyage to Mars assumes deeper resonances.

We do not see the journey in "Omnilingual"; the story begins with a crack team of scientists already combing the surface. They encounter the remnants of an advanced civilization, long extinct. The group included Martha Dane, an archaeologist with a particular fixation: learning to read the language of the Martians. Finding markings on the walls that she took to be writing, she developed a systematic transliteration into the Latin alphabet, transcribing Martian via a syllabary consisting of vowel-consonant pairs. Like the astounding "cracking" of Linear B by Michael Ventris in the early 1950s—just a few years before Piper put pen to paper—Dane hoped to figure out the referents for these signs. Ventris was aided by some inspired guessing about place names and then the surprising discovery, against expectation, that Linear B was simply a syllabic rendering of Greek.[2] Dane had no such luck. She needed something like a code-book, an analog to the Rosetta Stone, whose inscriptions in Egyptian hieroglyphs, Demotic Egyptian, and Greek enabled Jean-François Champollion to become, in 1824, the first human in over a millennium to actually read ancient Egyptian script. Sadly, for Martha Dane, "There is no Rosetta Stone, not anywhere on Mars.[. . .] We'll find one. There must be something, somewhere, that will give us the meaning of a few words, and we'll use them to pry meaning out of more words, and so on."[3] But since there could be no possible bilingual text between Martian and *any* Earth language, her colleagues dismissed her dream as a fantasy.

The team entered a massive building, which they speculated must have been something like a university. The group split up to explore different wings, and Dane wandered through rooms, transliterating Martian along the way, until she turned a corner and stood struck still by an inscription. "There was something familiar about the table on the left wall," the narrator tells us. "She tried to remember what she had been taught in school about physics, and what she had picked up by accident afterward. The second column was a continuation of the first: there were forty-six items in each, each item numbered consecutively—"

Dane counted the number of cells, and reached 92. That seemed interesting. What consisted of 92 items? The number of naturally occurring chemical elements, capped by uranium! She started at the top: "Hydrogen was Number One, she knew; One, *Sarfaldsorn*. Helium was Two; that was *Tirfaldsorn*."[4] From here on, nothing could stop Dane; she had found her Rosetta Stone, and from there could move to other scientific "bilinguals"—"astronomical tables, tables in physics and mechanics, for instance—in which words and numbers were equivalent." Most of her teammates were instantly convinced. Yet the leader Selim, a scholar of ancient Hittite, expressed some skepticism about the Martian Rosetta: "How do you know that their table of elements was anything like ours?" The three natural scientists on the team stared at him in disbelief. One, Mort Tranter, responded: "That isn't just the Martian table of elements; that's *the* table of elements. It's the only one there is."[5] (Dmitrii Mendeleev and Lothar Meyer might have begged to differ.) Finally, the colleague who had given Dane the hardest time, Hubert Penrose, granted her the highest of praise: "This is better than a bilingual, Martha. Physical science expresses universal facts; necessarily it is a universal language."[6]

We have come a long way from worries about whether one could even *do* science in Latin rather than Greek, or whether science would be destroyed by a Babel of languages. Rather than language serving as a barrier to block transmission of science (as the Esperantists and Idists argued at the dawn of the twentieth century) or averting Babel through the imposition of a unifying natural language (English, say, at the moment that I am writing this, or Latin several centuries earlier), we see Sapir and Piper, writing on either side of the linguistic chasm of World War II, expressing a common assumption: Science isn't just written *in* language, it is itself a language. The continually evolving and dynamic history of languages and the science conducted within them indicates that this proposition is most likely false, or at least deeply ambivalent. Nonetheless, the idea that mathematics or the facts of the physical and biological sciences alone might prove a "universal language" is omnipresent; the idea itself emerges from the rise and fall of Scientific Babels across the centuries. To further explore this notion, we must shift our gaze away from the past and examine how contemporaries think about language and science in our future.

The most common question along these lines is whether something can displace English from its current dominance in the natural sciences (and perhaps soon in the social sciences and humanities). All anyone

can do is guess about the way this situation might evolve, because there is no historical precedent for today's Anglophonia.[7] There are essentially three ways of thinking through the possibilities. The first is that the status quo will continue into the future.[8] This is entirely possible, although of course languages change over time, and when someone says "English" will continue to be the dominant language of the sciences, this allows for both the possibility that the current reduced dialect of "scientific English" will persevere and the alternative that scientific English will mirror inevitable changes in global English. In the annals of science fiction, it takes an apocalypse on the order of global thermonuclear war, a genetically engineered plague, an alien invasion, or some combination of the three to displace English, breaking it up into mutually unintelligible daughter languages.[9]

A second view is that scientific English will be replaced by a scientific dialect of another language, so that science would remain monoglot, just in a different tongue. This was the aspiration of the Esperantists, and all the other visionaries who hoped that a constructed auxiliary would eliminate the Babel generated by the ethnic languages. Those who anticipate this possibility have one candidate in mind: Chinese![10] (They apparently refer to Mandarin Chinese in its Beijing variant. Chinese is no less fluid and multivariant than English.[11]) The major argument for Chinese being the single language of future science is based on population and geopolitical power, yet there are two problems with these inferences: one empirical, and the other theoretical. The empirical problem is that, despite the rapidly increasing number of Chinese scientists and engineers, they are actually a major component in the contemporary growth of *English*, because most of their publications appear in that language, not Chinese.[12] The theoretical problem is more to the point: why on earth should we expect that science will be monolingual in the future? It certainly was not the case in the past. Even Latin, recall, was not the sole vehicular language in Europe except for the high Renaissance. As for reasoning based on population—if that were sufficient, then surely Spanish would have occupied a place as one of the major languages of science. That this has not been the case is telling.

A widespread, but controversial, way of thinking about linguistic diversity is to make an analogy to ecology.[13] A brief reflection brings up dozens of examples, ranging from language growth and competition, to endangered languages and language death. But languages are not precisely analogous to biological species. Languages do not "die" or go "extinct"; the native-speaking people using the language do, sometimes violently.[14] The language, if it is documented, can still be used. (Witness, again, our old friend Latin.) To those who think of languages as functioning in a global ecology, however, the transition to a single dominant language for science is a linguistic Green Revolution equivalent to the eradication of traditional agricultural systems, imposing monoculture for the sake of efficiency but potentially imperiling precisely the intellectual diversity (shades of Whorf here!) that can generate new scientific ideas.[15] This is an alluring argument, but it is impossible to evaluate without a sense of how science might have looked had English not become the single global scientific language over the past half century. Barring a counterfactual crystal ball, we can simply observe that an awful lot of science is currently being done, and scientists do not seem overly concerned about a dearth of new ideas. Behind this worry about monocultures is an abiding worry about monolingualism, one which adheres to the assumption that such a state is perhaps inevitable into the distant future. It is, in short, a lament.

It seems just as, if not more, likely, projecting the past into the future, that we will have several languages of science, not one—that if English were to lose its dominance, it might follow the pattern of Latin and break up into several vehicular languages, while still retaining significant currency. (That would be essential in order to access past secondary literature: as demonstrated by the attempts to preserve German in the Cold War, or the retention of Latin long after the onset of the Protestant Reformation.) One could imagine a future of Chinese, English, and Spanish or Portuguese. Would it look so different from our past? There would surely be hand-wringing about the lost position of English, new schemes for artificial languages to blend the dominant tongues, and a lot of effort expended in language learning and translation.

All of this assumes, of course, that the history we have seen in this book is irreversible. Yet there remain those (although fewer every year) who hope that we might be able to re-Babelize science just a smidgen, just as far back as restoring the triumvirate of English, French, and German (and skipping, *bien sûr* and *natürlich*, impossible languages like Russian). To the extent that words are met with deeds in this regard, we see an inverse of the Cold War pattern; at that time, the French by and large acquiesced to the eclipse of their language as a vehicular tongue for science, while the Germans attempted to staunch the damage they perceived as caused by Hitler's regime. Today, there is some backlash against English as the sole scientific language within German-speaking Europe—the topic surfaces periodically in newspapers, especially as

it concerns science education in secondary schools—but the state has put only limited resources behind promoting German abroad, and German-speaking scientists continue to publish in English.[16]

In France you are more likely to come across metaphors of cultural genocide: "It would be a national drama of incalculable consequences to remove from the French language its character as a scientific language."*[17] Despite the obvious fact that most Francophone scientists today are publishing in English, a discourse of resistance (often harkening back to the public mythology of the French Resistance against the Nazis) crops up fairly regularly.[18] While French truly is the only language besides English to have a global reach and a distinguished, centuries-long tradition in the natural sciences, nonetheless a French author trades communication for identity when she publishes in her native language—with certain notable exceptions.[19] Mathematics is a field where publication in French is still quite common. Laurent Lafforgue—winner of the 2002 Fields Medal—notes that French math is so strong that people will still read French to get at it; in fact, "it is to the degree that the French mathematical school remains attached to French that it conserves its originality and its force. *A contrario*, France's weaknesses in certain scientific disciplines could be ascribed to linguistic dereliction."†[20] The richness of metaphor and quickness of thought in one's native language enable creative work; identity should not be sacrificed without a fight. Yet dialing the hands of the clock back to the mid-nineteenth century seems extremely improbable.

The alternative is less likely to be full-blown multilingual publication than computer-mediated Machine Translation among several different tongues. In January 2012, former President of Harvard University, Lawrence Summers, famously dismissed "the substantial investment necessary to speak a foreign tongue" as not "universally worthwhile" given "English's emergence as a global language, along with the rapid progress in machine translation and the fragmentation of languages spoken worldwide."[21] Bypassing the non sequitur of how global fragmentation of languages would aid communication, Summers's point about MT seems to many a reasonable solution to the tensions explored

*"Ce serait un drame national aux conséquences incalculables que d'enlever à la langue française son caractère de langue scientifique."

†"c'est dans la mesure où l'école mathématique française reste attachée au français qu'elle conserve son originalité et sa force. *A contrario*, les faiblesses de la France dans certains disciplines scientifiques pourraient être liées au délaissement linguistique."

in this book: you can keep your identity by using your native tongue, and let computers take care of the communication. When we last left MT, it had collapsed into disgrace following the disappointed censure of the ALPAC report of 1966. Obviously, a lot has changed in the digital world since then. In particular, the single greatest roadblock for Léon Dostert's brand of MT—the scarcity of memory—has vanished. Memory has become dirt cheap. The speed of computation, expressed in the frenetically doubling euphoria of "Moore's Law"—which enthusiasts for an MT-utopia believe will continue indefinitely—has enabled completely different statistical approaches to computerized translation of natural languages, such as Google Translate, which relies not on an algorithmic decision-tree but on brute-force statistical comparison.[22] To casual observers, it looks like the language barrier is a thing of the past; computers are no longer "English-only," and even though computer languages and the language of computer science are dominated by English, the monolingual stranglehold on this area appears to be weakening.[23] Yet it seems less than certain that problems of Scientific Babel, and its current solution in English, can or will be transcended through these means. The significant challenges of access to computing technology in the poorer regions of the world probably matter less for the admittedly elite community of scientists, but the substantial infrastructure of education and publication already extant in English does likely entail that continuing to learn English will be more economical than translating everything multiple times among several thousand languages. There is a yet deeper difficulty with Summers's vision, which concerns how statistical MT actually works. Push a little harder on Google Translate, and one thing is evident: it is utterly dependent on human translation to provide the bilingual texts for statistical comparison. Hidden beneath our current MT, in other words, is more cover-to-cover. *Plus ça change*.

Set aside the future, and let's return to the present on our way back to the past. Both Sapir and Piper insisted upon the idea that science itself—whether expressed in terms of mathematics or purely in the sense impressions beloved of Logical Positivists in interwar Vienna—can serve as a kind of language to enable communication. Scientists are currently (and have been for fifty years) operationalizing this postulate into the foundation of one of the most breathtakingly visionary of contemporary scientific ventures: the Search for Extra-Terrestrial Intelligence (SETI). For the purposes of the subfield, "intelligence" is essentially synonymous with "ability to communicate," in part for epis-

temological reasons: we search for life in the cosmos by monitoring various frequency bands in all directions that are deemed to be the most likely carrier waves for deliberate interstellar communication; that implies that making contact is identical to receiving a message. This is, in short, a judgment about language.[24]

A fundamental postulate of SETI is that the intellectual problems that we have in composing a message for the heavens and understanding an incoming one are symmetric. That is, if we have difficulty assembling a text that can be understood *as a message in language* by intelligent beings that share neither our genetic capacities for tongues or any of the historical flotsam and jetsam of our present-languages, then so will the aliens. The quest quickly reduces to finding a metalanguage beyond our contingent languages and then monitoring the skies for any messages that might be broadcast in such a metalanguage. Already in 1921, Edward Sapir suggested that science might be that medium. Or, as expressed by a leading SETI practitioner in 2010: "By common consent, mathematics, being culturally neutral and forming the basis of the universal laws of nature, would be the lingua franca of interstellar discourse."[25]

This scientific-mathematical linguistic assumption—that is, that science and mathematics *are* a language—brings us to one fitting place to close this history of the languages in which modern science has been done. SETI is science being pursued today across the globe for the purposes of transcending an even more ineradicable language barrier than that which confronted Wilhelm Ostwald or Lise Meitner or Antoine Lavoisier in the past. There are, of course, thousands of objections that one might level at this enterprise, including the obvious fact that we have not yet figured out how to communicate terribly effectively with relatively intelligent animals occupying our own planet, not to mention other humans who share your scientific mindset and disciplinary training but happen to have been born in, say, Prague instead of San Francisco.[26] But rather than closing this book with a recitation of problems and rebuttals, let us return to the history of science.

In 1960, a Dutch mathematician named Hans Freudenthal published (in English, of course) the last constructed language we will take up in this volume, dubbed "Lincos" (for "Lingua Cosmica," a nod to Latin). If SETI scientists were looking for a likely interstellar signal, Freudenthal proffered the text—or at least the language in which such a text could be written. This was a language expressed through symbols and devoid of all of the features of either "natural" or "artificial" ones (Freudenthal's terms) besides semantics. This was a language about conveying *meaning*; everything else was superfluous. Yet even Freudenthal would not go so far as to think of mathematics as a language in itself: "It is true that mathematical language as written in textbooks still parasitizes on natural languages. The text surrounding the mathematical formulas is usually written in an idiom that bears the characteristics of the vernacular, to which it belongs in the ordinary sense."[27] But he needed to get beyond vernacular, to convey "in principle the whole bulk of our knowledge," not just selected proofs. Lincos would be considered understood by the recipient if he (Freudenthal's choice of pronoun) could "operate on it," manipulate it to generate other phrases in it—a decent enough definition of scientific language, come to think of it.[28] Lincos, in being communicated, taught itself through itself, building on "facts which may be supposed to be known to the receiver."[29]

What might those be? Carl Sagan and Iosif Shklovskii—guiding spirits of American and Soviet SETI, respectively—praised Freudenthal's efforts with Lincos and speculated about how precisely we might begin our Lincos messages. Pictures might be best, assuming that vision was a reasonably likely evolutionary trait no matter where you were in the universe, and there was one picture that seemed particularly apt. "For example, Mendeleyev's periodic system of the elements could be pictured, accompanied by the corresponding words in Lincos," they wrote. "The number and distribution of electrons, of course, would indicate the nature of the atom. Then, a graph of the number of protons in the nucleus versus the number of neutrons could be transmitted. By this time, the cosmic discourse is well along into atomic and nuclear physics."[30]

Would Mendeleev and Meyer, who wrangled about which words could and should properly characterize the periodic system in Russian and German, be flattered or flummoxed that the system they fought over was now understood to be beyond language, beyond Earth? Is the idea so strange? H. Beam Piper imagined Martha Dane communicating with dead aliens by using lists of elements. We can indeed picture such an eventuality in a time far in the future, or on a world millions of miles away. Yet for the present, as in the past, we remain bound to the constraints of history, to the shackles of the words in human languages: untranslatable yet intelligible, frustrating yet infinitely beguiling.

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Parts of four chapters of this book were published as scholarly articles, and I acknowledge the journals who printed them and their granting

of the right to republish some of that material here, in revised form: "Translating Textbooks: Russian, German, and the Language of Chemistry," *Isis* 103 (2012): 88–98; "The Table and the Word: Translation, Priority, and the Periodic System of Chemical Elements," *Ab Imperio*, no. 3 (2013): 53–82; and "The Dostoevsky Machine in Georgetown: Scientific Translation in the Cold War," *Annals of Science* 72 (forthcoming 2015).

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ARCHIVES

The notes make reference to several archival collections, sometimes in abbreviated form. The full citations to all archives are presented here, with their accompanying abbreviation, when necessary.

Austria

Esperantomuseum of the Österreichische Nationalbibliothek, Herrengasse 9, 1010 Vienna.

Germany

[AMPG] Archives of the Max-Planck-Gesellschaft, Boltzmannstraße 14, 14195 Berlin.

[BBAW] Archives of the Berlin-Brandenburgische Akademie der Wissenschaften, Jägerstraße 22, 10117 Berlin.

[FUA] University Archives of the Freie Universität zu Berlin, Malteserstraße 74–100, Bldg. L, 12249 Berlin.

[HBA] Hofbibliothek und Stiftsbibliothek Aschaffenburg, Hugo-Dingler Stiftung, Schloßplatz 4, 63769 Aschaffenburg.

[HUA] Archives of the Humboldt-Universität zu Berlin, Eichborndamm 113, 13403 Berlin.

Russia

[ADIM] Archive-Museum of D. I. Mendeleev, St. Petersburg State University, Mendeleevskaia liniia 2, St. Petersburg 199034.

[PFARAN] St.-Peterburg Branch of the Archive of the Russian Academy of Sciences, Universitetskaia nab. 1, St. Petersburg 199034.

[TsGIASPb] Central State Historical Archive of St. Petersburg, Pskovskaia ulitsa 18, St. Petersburg 190121.

[*ZhRFKhO*] *Zhurnal Russkogo Fiziko-Khimicheskogo Obshchestva* [Journal of the Russian Physico-Chemical Society].

United States of America

[AEDA] Albert Einstein Duplicate Archive, Princeton University Library, Rare

Books and Special Collections, Princeton University, Princeton, New Jersey 08544.
[AIP] Niels Bohr Library and Archives, American Institute of Physics, 1 Physics Ellipse Drive, College Park, Maryland 20740.
[APSL] American Philosophical Society Library, 105 S. 5th Street, Philadelphia, Pennsylvania 19106.
[GUA] Georgetown University Archives, Lauinger Library, Georgetown University, 3700 O Street NW, Washington, DC 20057.
[-SLL] School of Languages and Linguistics
[-MTP] Machine Translation Papers
[LOC] Library of Congress Manuscript Division, 101 Independence Avenue SE, Room LM 101, James Madison Memorial Building, Washington, DC 20540.
[MIT] Massachusetts Institute of Technology Archives and Special Collections, Building 14N-118, 77 Massachusetts Avenue, Cambridge, MA 02139.
[NARA] National Archives and Records Administration, 8601 Adelphi Road, College Park, Maryland 20740.

NOTES

Introduction

1. Jean Le Rond D'Alembert, *Discours préliminaire de l'Encyclopédie*, ed. Michel Malherbe (Paris: J. Vrin, 2000), 137.

2. The invisibility of translation (and translators) is the central point in Lawrence Venuti, *The Translator's Invisibility: A History of Translation*, 2d ed. (London: Routledge, 2002 [1995]). See also David Bellos, *Is That a Fish in Your Ear? Translation and the Meaning of Everything* (New York: Faber and Faber, 2011). Although most works in translation studies focus on humanistic or literary translation, there is no reason to believe that the general issues do not also apply in the sciences. See I. J. Citroen, "The Myth of the Two Professions: Literary and Non-Literary Translation," *Babel* 11 (1965): 181–188.

3. On medicine, see John Maher, "The Development of English as an International Language of Medicine," *Applied Linguistics* 7 (1986): 206–218.

4. On the particular difficulties of "*Wissenschaft*" in German, see Denise Phillips, *Acolytes of Nature: Defining Natural Science in Germany, 1770–1850* (Chicago: University of Chicago Press, 2012), 4.

5. On the equivalent trends in the social sciences, see Abram De Swaan, "English in the Social Sciences," in Ulrich Ammon, ed., *The Dominance of English as a Language of Science: Effects on Other Languages and Language Communities* (Berlin: Mouton de Gruyter, 2001), 71–83; Ulrich Ammon, "Kaum noch ein Prozent Weltanteil in den Naturwissenschaften: Über Deutsch als Wissenschaftssprache," *Forschung und Lehre* (June 2010): 318–320, on 319.

6. I build gratefully on earlier scholarship on these questions. Most of it, with the exception of Scott L. Montgomery, *Science in Translation: Movements of Knowledge through Cultures and Time* (Chicago: University of Chicago Press, 2000), has approached the issue of language barriers and language spread in the sciences from a more sociological viewpoint, not a historical one. A partial list of the most important works includes Ammon, *The Dominance of English as a Language of Science*; J. A. Large, *The Foreign-Language Barrier: Problems in Scientific Communication* (London: André Deutsch, 1983); Conseil de la langue française, Gouvernement du Québec, *Le français et les langues scientifiques de demain: Actes du colloque tenu à l'Université du Québec à Montréal du 19 au 21 mars 1996* (Quebec, Canada: Gouvernment du Québec, 1996); Sabine Skudlik, *Sprachen in den Wissenschaften: Deutsch und Englisch in der internationalen Kommunikation* (Tübingen: Gunter Narr, 1990); and Hubert Fon-

din, "La langue de la publication scientifique: la prépondérance de l'anglais et la recherche," *Documentation et bibliothéques* (June 1979): 59–69.

7. This problem has been the central concern of the entire theoretical field of hermeneutics. For an especially clear introduction, see Naoki Sakai, *Translation and Subjectivity: On 'Japan' and Cultural Nationalism* (Minneapolis: University of Minnesota Press, 1997), 1–17.

8. Clarence Augustus Manning, "Language and International Affairs," *Sewanee Review* 32, no. 3 (July 1924): 295–311, on 296.

9. A corollary of this point is that all contemporary scientists except Anglophones have to be bilingual, and even native Anglophones have to use a highly specialized and stereotyped scientific English, which makes them diglossic. On the notion of "diglossia"—typically used to refer to related dialects/languages stratified by class (Swiss-German/German, Haitian-Creole/French)—see the classic essay by Charles A. Ferguson, "Diglossia," *Word* 15 (1959): 325–340. On the general prevalence of multilingual rather than monoglot behavior, see John McWhorter, *The Power of Babel: A Natural History of Language* (New York: Perennial, 2001), 63; and Craig Calhoun, *Nationalism* (Minneapolis: University of Minnesota Press, 1997), 19, 41.

10. Derek J. de Solla Price, *Science since Babylon*, enlarged ed. (New Haven: Yale University Press, 1975 [1961]).

11. Minoru Tsunoda, "Les langues internationales dans les publications scientifiques et techniques," *Sophia Linguistica* (1983): 70–79.

12. Rainer Enrique Hamel, "The Dominance of English in the International Scientific Periodical Literature and the Future of Language Use in Science," *AILA Review* 20 (2007): 53–71, on 63; and J. Garrido, "Scientific and Technical Publications in the Lesser Known Languages," *Science East to West* 5, no. 14 (April 1964): 1–6, on 2.

13. For some studies which use language in this more metaphorical sense, see Matthias Dörries, "Language as a Tool in the Sciences," in Dörries, ed., *Experimenting in Tongues: Studies in Science and Language* (Stanford: Stanford University Press, 2002): 1–20; Peter Galison, "Trading Zone: Coordinating Action and Belief," in Mario Biagioli, ed., *The Science Studies Reader* (New York: Routledge, 1999): 137–160; Theodore H. Savory, *The Language of Science: Its Growth, Character, and Usage* (London: André Deutsch, 1953); and Maurice P. Crosland, *Historical Studies in the Language of Chemistry* (Cambridge, MA: Harvard University Press, 1962).

14. I also manage Spanish, Modern Hebrew, and some Czech, but those are, for reasons this book addresses, not dominant scientific languages.

15. On the essential distinction between written and spoken competence, see Skudlik, *Sprachen in den Wissenschaften*, 25; and Herbert Newhard Shenton, *Cosmopolitan Conversation: The Language Problems of International Conferences* (New York: Columbia University Press, 1933).

16. Ralph A. Lewin and David K. Jordan, "The Predominance of English and the Potential Use of Esperanto for Abstracts of Scientific Articles," in M. Kageyama, K. Nakamura, T. Oshima, and T. Uchida, eds., *Science and Scientists: Essays by Biochemists, Biologists, and Chemists* (Tokyo: Japan Scientific Societies Press, 1981): 435–441, on 438. The results are very robust. See, for example, Ulrich Ammon, "Linguistic Inequality and Its Effects on Participation in Scientific Discourse and on Global Knowledge Accumulation—With a Closer Look at the Problems of the Second-Rank Language Communities," *Applied Linguistics Review* 3, no. 2 (2012): 333–355; Large, *The Foreign-Language Barrier*, 32; Graham K. L. Chan, "The Foreign Language Barrier in Science and Technology," *International Library Review* 8 (1976): 317–325, on 321–322; and C. M. Louttit, "The Use of Foreign Languages by Psychologists, Chemists, and Physicists," *American Journal of Psychology* 70, no. 2 (June 1957): 314–316.

17. Richard B. Baldauf, Jr. and Björn H. Jernudd, "Language of Publications as a Variable in Scientific Communication," *Australian Review of Applied Linguistics* 6 (1983): 97–108, on 97.

18. Savory, *The Language of Science*, 113; a similar statement occurs on p. 107.

19. See, for example, Hans Niels Jahnke and Michael Otte, "On 'Science as a Language,'" in Jahnke and Otte, eds., *Epistemological and Social Problems of the Sciences in the Early Nineteenth Century* (Dordrecht: D. Reidel, 1981): 75–89.

20. Sundar Sarukkai, *Translating the World: Science and Language* (Lanham, MD: University Press of America, 2002), 7; Montgomery, *Science in Translation*, 254.

21. S. Chandrasekhar, *Newton's* Principia *for the Common Reader* (Oxford: Clarendon Press, 1995), 36.

22. Isaac Newton, *The* Principia*: Mathematical Principles of Natural Philosophy*, tr. I. Bernard Cohen and Anne Whitman (Berkeley: University of California Press, 1999), 700. Emphasis in original.

23. Isaac Newton, *Philosophiae naturalis principia mathematica*, 2d ed. (Cambridge, 1713), 571.

24. On multilingualism among mathematicians in this period, see Jeremy J. Gray, "Languages for Mathematics and the Language of Mathematics in a World of Nations," in Karen Hunger Parshall and Adrian C. Rice, eds., *Mathematics Unbound: The Evolution of an International Mathematical Research Community, 1800–1945* (Providence: American Mathematical Society and London Mathematical Society, 2002): 201–228.

25. Henri Poincaré, *Sechs Vorträge über ausgewählte Gegenstände aus der reinen Mathematik und mathematischen Physik, auf Einladung der Wolfskehl-Kommission der Königlichen Gesellschaft der Wissenschaften gehalten zu Göttingen vom 22.-28. April 1909* (Leipzig: B. G. Teubner, 1910), 51. I thank Michael Barany for bringing this citation to my attention.

26. I call this view "Whorfian" rather than the "Sapir-Whorf Hypothesis," because it is not at all clear that Whorf's teacher, the distinguished linguist Edward Sapir, actually held it. On the history of the hypothesis, see John E. Joseph, "The Immediate Sources of the 'Sapir-Whorf Hypothesis,'" *Historiographia Linguistica* 23, no. 3 (1996): 365–404.

27. Benjamin Lee Whorf, "Science and Linguistics," *Technology Review* 42 (1940), reproduced in John B. Carroll, ed., *Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf* (Cambridge, MA: MIT Press, 1956), 214.

28. For a summary of the data, see Paul Kay and Willett Kempton, "What Is the Sapir-Whorf Hypothesis?," *American Anthropologist* 86 (1984): 65–79. Guy Deutscher, in *Through the Language Glass: Why the World Looks Different in Other Languages* (New York: Metropolitan Books, 2010), argues for some Whorfian effects. The arguments pro and con are usefully and impartially parsed in G. E. R. Lloyd, *Cognitive Variations: Reflections on the Unity and Diversity of the Human Mind* (Oxford: Clarendon, 2007).

29. See, for example, Jessica Riskin, "Rival Idioms for a Revolutionized Science

and a Republican Citizenry," *Isis* 89 (1998): 203–232; Lissa Roberts, "Condillac, Lavoisier, and the Instrumentalization of Science," *Eighteenth Century* 33 (1992): 252–271; idem, "A Word and the World: The Significance of Naming the Calorimeter," *Isis* 82, no. 2 (June 1991): 198–222; Trevor H. Levere, "Lavoisier: Language, Instruments, and the Chemical Revolution," in Levere and William R. Shea, eds., *Nature, Experiment, and the Sciences* (Dordrecht: Kluwer Academic, 1990): 207–223; and Marco Beretta, *The Enlightenment of Matter: The Definition of Chemistry from Agricola to Lavoisier* (Canton, MA: Science History Publications, 1993). For a general survey of the varied historiography of this episode, see John G. McEvoy, *The Historiography of the Chemical Revolution: Patterns of Interpretation in the History of Science* (London: Pickering & Chatto, 2010).

30. Antoine Lavoisier, "Mémoire sur la nécessité de réformer et de perfectionner la nomenclature de la chimie," in *Œuvres de Lavoisier* (Paris: 1864–1893): V:354–364, on 356.

31. See, among others, Marc Fumaroli, *When the World Spoke French*, tr. Richard Howard (New York: New York Review Books, 2011 [2001]).

32. David C. Gordon, *The French Language and National Identity (1930–1975)* (The Hague: Mouton, 1978), 22–27.

33. Fumaroli, *When the World Spoke French*, xviii.

34. Gordon, *The French Language and National Identity*, 35; R. E. Keller, *The German Language* ([Atlantic Highlands], NJ: Humanities Press, 1978), 486.

35. Comte de Rivarol, *L'Universalité de la langue française* (Paris: Arléa, 1991 [1784]), 27.

36. On Schwab, see Edwin H. Zeydel, "A Criticism of the German Language and Literature by a German of the Eighteenth Century," *Modern Language Notes* 38, no. 4 (April 1923): 193–201; idem, "Johann Christoph Schwab on the Relative Merits of the European Languages," *Philological Quarterly* 3 (1924): 285–301; and Freeman G. Henry, "From the First to the Fifth Republic: Antoine de Rivarol, Johann Christoph Schwab, and the Latest 'Lingua Franca,'" *French Review* 77, no. 2 (December 2003): 312–323.

37. Rivarol, *L'Universalité de la langue française*, 72–73. Emphasis in original.

38. J. C. Schwab, *Le Grand Concours: "Dissertation sur les causes de l'universalité de la langue française et la durée vraisemblable de son empire,"* tr. Denis Robelot, ed. Freeman G. Henry (Amsterdam: Rodopi, 2005), 142.

39. David A. Bell, "Lingua Populi, Lingua Dei: Language, Religion, and the Origins of French Revolutionary Nationalism," *American Historical Review* 100, no. 5 (December 1995): 1403–1437; idem, *The Cult of the Nation in France: Inventing Nationalism, 1680–1800* (Cambridge, MA: Harvard University Press, 2001), chapter 6; Patrice L.-R. Higonnet, "The Politics of Linguistic Terrorism and Grammatical Hegemony during the French Revolution," *Social History* 5, no. 1 (January 1980): 41–69; Peter Flaherty, "*Langue nationale/langue naturelle*: The Politics of Linguistic Uniformity during the French Revolution," *Historical Reflections/Réflexions historiques* 14, no. 2 (Summer 1987): 311–328; Martyn Lyons, "Politics and Patois: The Linguistic Policy of the French Revolution," *Australian Journal of French Studies* 18 (1981): 264–281; and Jean-Yves Lartichaux, "Linguistic Politics during the French Revolution," *Diogenes* 25 (1977): 65–84.

40. Robert E. Schofield, *The Enlightenment of Joseph Priestley: A Study of His Life and Work from 1733 to 1773* (University Park: Pennsylvania State University Press, 1997), 79–80, 232.

41. Maurice Crosland, *In the Shadow of Lavoisier: The* Annales de Chimie *and the Establishment of a New Science* (Oxford: Alden Press, 1994), 88.

42. Arthur Donovan, *Antoine Lavoisier: Science, Administration and Revolution* (Cambridge: Cambridge University Press, 1993), 30.

43. J. B. Gough, "Lavoisier's Early Career in Science: An Examination of Some New Evidence," *British Journal for the History of Science* 4, no. 1 (June 1968): 52–57; McEvoy, *The Historiography of the Chemical Revolution*, 98. See also J. B. Gough, "Lavoisier and the Fulfillment of the Stahlian Revolution," *Osiris* 4 (1988): 15–33.

44. Donovan, *Antoine Lavoisier*, 95; Henry Guerlac, *Lavoisier—The Crucial Year: The Background and Origin of His First Experiments on Combustion in 1772* (Ithaca: Cornell University Press, 1961), 13, 15–16, 28, 52, 65.

45. Robert E. Schofield, *The Enlightened Joseph Priestley: A Study of His Life and Work from 1773 to 1804* (University Park: Pennsylvania State University Press, 2004), 105.

46. Jan Golinski, "The Chemical Revolution and the Politics of Language," *Eighteenth Century* 33, no. 3 (1992): 238–251, on 241; Jean-Pierre Poirier, *Lavoisier: Chemist, Biologist, Economist*, tr. Rebecca Balinski (Philadelphia: University of Pennsylvania Press, 1996 [1993]), 180. Madame Lavoisier also translated Italian commentaries on chemistry for her husband, as discussed in Marco Beretta, "Italian Translations of the *Méthode de Nomenclature Chimique* and the *Traité Élémentaire de Chimie*: The Case of Vincenzo Dandolo," in Bernadette Bensaude-Vincent and Ferdinando Abbri, eds., *Lavoisier in European Context: Negotiating a New Language for Chemistry* (Canton, MA: Science History Publications, 1995): 225–247, on 228.

47. Translator's preface to Richard Kirwan, *Essai sur le phlogistique, et sur la constitution des acides, traduit de l'anglois de M. Kirwan; avec des notes de MM. de Morveau, Lavoisier, de la Place, Monge, Berthollet, & de Fourcroy* (Paris: Rue et Hôtel Serpente, 1788), vii.

48. Donovan, *Antoine Lavoisier*, 175.

49. Bensaude-Vincent and Abbri, *Lavoisier in European Context*; Crosland, *Historical Studies in the Language of Chemistry*, 191, 208–209; Beretta, *The Enlightenment of Matter*, 302–303, 319.

50. Albert Léon Guérard, *A Short History of the International Language Movement* (London: T. Fisher Unwin, 1922), 88.

Chapter One

1. Lucretius, *De rerum natura*, ed. W. H. D. Rouse and Martin Ferguson Smith (Cambridge, MA: Harvard University Press, 1992 [1924]), I:136–139.

2. This litmus-test quality is nicely observed in Leslie Dunton-Downer, *The English Is Coming! How One Language Is Sweeping the World* (New York: Touchstone, 2010), 200. For those who see English as functioning very much like Latin, see Roger Balian, "Le physicien français et ses langages de communication," in Conseil de la langue française, Gouvernement du Québec, *Le français et les langues scientifiques de demain: Actes du colloque tenu à l'Université du Québec à Montréal du 19 au 21 mars*

1996 (Quebec, Canada: Gouvernment du Québec, 1996): 43–53, on 43; Clarence Augustus Manning, "Language and International Affairs," *Sewanee Review* 32, no. 3 (July 1924): 295–311, on 309; and James Clackson and Geoffrey Horrocks, *The Blackwell History of the Latin Language* (Malden, MA: Blackwell, 2007), 77. For scholars who dispute the analogy, see Sabine Skudlik, *Sprachen in den Wissenschaften: Deutsch und Englisch in der internationalen Kommunikation* (Tübingen: Gunter Narr, 1990), 9–10; and Hanno Helbling, "Aspekte des Verhältnisses von Wissenschaft und Sprache," in Hartwig Kalverkämper and Harald Weinrich, eds., *Deutsch als Wissenschaftssprache: 25. Konstanzer Literaturgespräch des Buchhandels, 1985* (Tübingen: Gunter Narr, 1986): 151–153, on 152.

3. On the terminological issues associated with "universal languages" and "lingua franca," among other categories, see Ulrich Ammon, "International Languages," in R. E. Asher, ed., *The Encyclopedia of Language and Linguistics*, vol. 4 (Oxford: Pergamon Press, 1994): 1725–1730; Conrad M. B. Brann, "Lingua Minor, Franca & Nationalis," in Ulrich Ammon, ed., *Status and Function of Languages and Language Varieties* (Berlin: Walter de Gruyter, 1989): 372–385; Henry Kahane and Renée Kahane, "*Lingua Franca*: The Story of a Term," *Romance Philology* 30 (August 1976): 25–41; and Nicholas Ostler, *The Last Lingua Franca: English until the Return of Babel* (New York: Walker, 2010). On English as Latin rather than a lingua franca, see Hans Joachim Meyer, "Global English—a New Lingua Franca or a New Imperial Culture?," in Andreas Gardt and Bernd Hüppauf, eds., *Globalization and the Future of German* (Berlin: Mouton de Gruyter, 2004): 65–84, on 72–73.

4. The history of Latin is very well documented, thanks to a continuous tradition of writing dating from antiquity and the assiduousness of generations of scholars. For a more formal study, see Clackson and Horrocks, *The Blackwell History of the Latin Language*; and L. R. Palmer, *The Latin Language* (London: Faber and Faber, [1954]). For more accessible accounts, see Nicholas Ostler, *Ad Infinitum: A Biography of Latin* (New York: Walker, 2007); Joseph B. Solodow, *Latin Alive: The Survival of Latin in English and the Romance Languages* (Cambridge: Cambridge University Press, 2010); and Tore Janson, *A Natural History of Latin* (New York: Oxford University Press, 2004). I draw extensively from all of these.

5. On this question, see J. N. Adams, *The Regional Diversification of Latin 200 BC–AD 600* (Cambridge: Cambridge University Press, 2007).

6. Clackson and Horrocks, *The Blackwell History of the Latin Language*, 79.

7. J. N. Adams, *Bilingualism and the Latin Language* (Cambridge: Cambridge University Press, 2003); Clackson and Horrocks, *The Blackwell History of the Latin Language*, 189; Erich Auerbach, *Literary Language and Its Public in Late Latin Antiquity and in the Middle Ages*, tr. Ralph Manheim (Princeton: Princeton University Press, 1965 [1958]), 248–249.

8. Geoffrey Horrocks, *Greek: A History of the Language and Its Speakers*, 2d. ed. (Malden, MA: Wiley-Blackwell, 2010 [1997]), 110; William V. Harris, *Ancient Literacy* (Cambridge, MA: Harvard University Press, 1989), 175; L. D. Reynolds and N. G. Wilson, *Scribes and Scholars: A Guide to the Transmission of Greek and Latin Literature*, 3d. ed. (Oxford: Clarendon Press, 1991 [1968]), 55.

9. I choose not to provide the diacritic over the "e," but readers should be aware that many accounts do, and that the word is pronounced with two syllables.

10. Bruno Rochette, *Le latin dans le monde grec: Recherches sur la diffusion de la langue et des lettres latines dans les provinces hellénophones de l'Empire romain* (Brussels: Latomus, 1997), especially 70 and 139.

11. On Latin and early Christianity, see Christine Mohrmann, *Latin vulgaire, Latin des chrétiens* (Paris: Librairie C. Klincksieck, 1952).

12. This quotation is from J. M. Millas-Vallicrosa, "Translations of Oriental Scientific Works (to the End of the Thirteenth Century)," tr. Daphne Woodward, in Guy S. Métraux and François Crouzet, eds., *Evolution of Science: Readings from the History of Mankind* (New York: New American Library, 1963): 128–167, on 128. On the "poverty topos" frequently invoked by Latins vis-à-vis Greek, see Joseph Farrell, *Latin Language and Latin Culture from Ancient to Modern Times* (Cambridge: Cambridge University Press, 2001), 28; and Ostler, *Ad Infinitum*, chapter 5.

13. On the Romans' natural knowledge—whether written in Latin or Greek—see Daryn Lehoux, *What Did the Romans Know? An Inquiry into Science and Worldmaking* (Chicago: University of Chicago Press, 2012). I am indebted for the point about popularization to David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D. 1450*, 2d. ed. (Chicago: University of Chicago Press, 2007 [1992]), 135; and Scott L. Montgomery, *Science in Translation: Movements of Knowledge through Cultures and Time* (Chicago: University of Chicago Press, 2000).

14. Cicero, *Tusculan Disputations*, ed. J. E. King (Cambridge, MA: Harvard University Press, 1950 [1927]), I.i.1.

15. Cicero, *Academica*, I.ii.4, in Cicero, *De natura deorum. Academica*, ed. H. Rackham (Cambridge, MA: Harvard University Press, 1951 [1933]), 414.

16. Cicero, *Academica*, I.iii.10, in Cicero, *De natura deorum. Academica*, 420.

17. Cicero, *Academica*, I.vii.25, in Cicero, *De natura deorum. Academica*, 434.

18. D. R. Langslow, *Medical Latin in the Roman Empire* (New York: Oxford University Press, 2000), esp. 35–36 for the contrast with Cicero; Rebecca Flemming, "Galen's Imperial Order of Knowledge," in Jason König and Tim Whitmarsh, eds., *Ordering Knowledge in the Roman Empire* (Cambridge: Cambridge University Press, 2007): 241–277, on 269.

19. Horrocks, *Greek*, 197, 207; Henry Kahane and Renée Kahane, "Decline and Survival of Western Prestige Languages," *Language* 55 (March 1979): 183–198, on 183–186.

20. Gilbert Dagron, "Formes et fonctions de pluralisme linguistique à Byzance (IXe-XIIe siècle)," *Travaux et mémoires* 12 (1994): 219–240.

21. Lindberg, *The Beginnings of Western Science*, 159.

22. On the rareness of knowledge of Greek in the West, see F. A. C. Mantello and A. G. Rigg, eds., *Medieval Latin: An Introduction and Bibliographical Guide* (Washington, DC: Catholic University of America Press, 1996), 718; Bernhard Bischoff, "The Study of Foreign Languages in the Middle Ages," *Speculum* 36, no. 2 (April 1961): 209–224, on 215; Reynolds and Wilson, *Scribes and Scholars*, 118–119; A. C. Dionisotti, "On the Greek Studies of Robert Grosseteste," in Dionisotti, Anthony Grafton, and Jill Kraye, eds., *The Uses of Greek and Latin: Historical Essays* (London: The Warburg Institute, 1988): 19–39; and idem, "Greek Grammars and Dictionaries in Carolingian Europe," in Michael W. Herren, ed., *The Sacred Nectar of the Greeks: The Study of Greek in the West in the Early Middle Ages* (London: King's College London Medieval Studies, 1988): 1–56.

23. Pierre Riché, "Le grec dans les centres de culture d'Occident," in Herren, ed., *The Sacred Nectar of the Greeks* (1988): 143–168; Marie-Thérèse D'Alverny, "Translations and Translators," in Robert L. Benson and Giles Constable, eds., *Renaissance and Renewal in the Twelfth Century* (Cambridge, MA: Harvard University Press, 1982): 421–462, on 427.

24. Lindberg, *The Beginnings of Western Science*, 147–148, 197.

25. Bischoff, "The Study of Foreign Languages in the Middle Ages," 209; Auerbach, *Literary Language and Its Public in Late Latin Antiquity*, 119–120, 269; Charles Homer Haskins, *The Renaissance of the Twelfth Century* (Cambridge, MA: Harvard University Press, 1955 [1927]), 127.

26. Dimitri Gutas, *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early 'Abbāsid Society (2nd–4th/8th–10th Centuries)* (New York: Routledge, 1998), 2.

27. Montgomery, *Science in Translation*, 106.

28. Reynolds and Wilson, *Scribes and Scholars*, 109; William Chester Jordan, *Europe in the High Middle Ages* (New York: Viking, 2001), 116.

29. Lindberg, *The Beginnings of Western Science*, 224; Mantello and Rigg, *Medieval Latin*, 506.

30. On the importance of science in this first generation of translations, see D'Alverny, "Translations and Translators," 451; Mantello and Rigg, *Medieval Latin*, 343.

31. On the Toledo translations, see Mantello and Rigg, *Medieval Latin*, 724–725; F. Gabrieli, "The Transmission of Learning and Literary Influences to Western Europe," in P. M. Holt, Ann K. S. Lambton, and Bernard Lewis, eds., *The Cambridge History of Islam*, v. 2 (Cambridge: Cambridge University Press, 1970): 851–889; Millas-Vallicros, "Translations of Oriental Scientific Works"; George F. Hourani, "The Medieval Translations from Arabic to Latin Made in Spain," *Muslim World* 62 (1972): 97–114.

32. John Murdoch, "Euclid: Transmission of the Elements," *Complete Dictionary of Scientific Biography* (Detroit: Charles Scribner's Sons, 2008), IV: 437–459; William R. Newman, *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (Chicago: University of Chicago Press, 2004), 43–44. On quality, see R. W. Southern, *The Making of the Middle Ages* (New Haven: Yale University Press, 1953), 65.

33. Haskins, *The Renaissance of the Twelfth Century*, 301. Emphasis in original.

34. Ostler, *Ad Infinitum*, 217; Reynolds and Wilson, *Scribes and Scholars*, 121.

35. Benedict Anderson, *Imagined Communities: Reflections on the Origin and Spread of Nationalism*, rev. ed. (London: Verso, 1991 [1983]), 38. This claim is accurate, but Anderson goes on to declare: "Then and now the bulk of mankind is monoglot." According to most definitions of linguistic competence, this is demonstrably untrue.

36. Peter Burke, *Languages and Communities in Early Modern Europe* (Cambridge: Cambridge University Press, 2004), 44–45.

37. See, especially, Michael Baxandall, *Giotto and the Orators: Humanist Observers in Italy and the Discovery of Pictorial Composition, 1350–1450* (Oxford: Clarendon Press, 1971), 9, 46. For more on this point, see Paul Botley, *Latin Translation in the Renaissance: The Theory and Practice of Leonardo Bruni, Giannozzo Manetti and Desiderius Erasmus* (Cambridge: Cambridge University Press, 2004), 152; Christopher S. Celenza, *The Lost Italian Renaissance: Humanists, Historians, and Latin's Legacy* (Baltimore: Johns Hopkins University Press, 2004), 144, 146.

38. Mantello and Rigg, *Medieval Latin*, 76; Jozef IJsewijn, *Companion to Neo-Latin Studies, Part I: History and Diffusion of Neo-Latin Literature*, 2d ed. (Leuven: Leuven University Press, 1990), 22.

39. Johan Huizinga, *Erasmus and the Age of Reformation* (New York: Harper & Brothers, 1957), 43.

40. Anthony Grafton, *Defenders of the Text: The Traditions of Scholarship in an Age of Science, 1450–1800* (Cambridge, MA: Harvard University Press, 1991), 166–167; Southern, *The Making of the Middle Ages*, 16.

41. On Sanskrit, see especially Sheldon Pollock, *The Language of the Gods in the World of Men: Sanskrit, Culture, and Power in Premodern India* (Berkeley: University of California Press, 2006). On the combination of European vehicular languages and regional vernacular translations of modern science in South Asia, see Michael S. Dodson, "Translating Science, Translating Empire: The Power of Language in Colonial North India," *Comparative Studies in Society and History* 47, no. 4 (October 2005): 809–835; and Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton: Princeton University Press, 1999), 62–63.

42. Frits Staal, "The Sanskrit of Science," *Journal of Indian Philosophy* 23 (1995): 73–127; Sheldon Pollock, "The Languages of Science in Early-Modern India," in Karin Preisendanz, ed., *Expanding and Merging Horizons: Contributions to South Asian and Cross-Cultural Studies in Commemoration of Wilhelm Halbfass* (Vienna: Verlag der Österreichischen Akademie der Wissenschaften, 2007): 203–220.

43. Hermann Jacobi, "Über den nominalen Stil des wissenschaftlichen Sanskrits," *Indogermanische Forschungen* 14 (1903): 236–251.

44. Otto Jespersen, *The Philosophy of Grammar* (Chicago: University of Chicago Press, 1992 [1924]), 139.

45. The classic and comprehensive history of traditional Chinese science is, of course, the work begun by Joseph Needham and continued by generations of scholars: Joseph Needham with Wang Ling, *Science and Civilisation in China* (Cambridge: Cambridge University Press, 1954–). On Chinese encounters with Catholic Jesuits and English Protestants from the sixteenth to the nineteenth century, and how the translations shaped this traditional learning, see Benjamin A. Elman, *On Their Own Terms: Science in China, 1550–1900* (Cambridge, MA: Harvard University Press, 2005).

46. For a general introduction to Chinese and common misconceptions about how it works, see John DeFrancis, *The Chinese Language: Fact and Fantasy* (Honolulu: University of Hawaii Press, 1984). On the extent to which written Chinese can be thought of as a lingua franca, see the helpful essay by Victor H. Mair, "Buddhism and the Rise of the Written Vernacular in East Asia: The Making of National Languages," *Journal of Asian Studies* 53, no. 3 (August 1994): 707–751. The general information in this paragraph about the circulation and limits of Classical Chinese, as well as the analogy with Latin, are drawn from Peter Kornicki, "The Latin of East Asia?," Lecture 1 of the 2008 Sandars Lectures in Bibliography, Cambridge University, 10 March 2008, available at http://www.lib.cam.ac.uk/sandars/kornicki1.pdf, accessed 10 August 2013.

47. For an introduction to the Chinese script, see Oliver Moore, *Chinese* (Berkeley: University of California Press, 2000). For how early modern Europeans understood Chinese writing, see the detailed discussion in Bruce Rusk, "Old Scripts, New

Actors: European Encounters with Chinese Writing, 1550–1700," *East Asian Science, Technology, and Medicine* 26 (2007): 68–116.

48. Reproduced in Marin Mersenne, *Correspondance*, ed. Cornelis de Waard, II (1628–1630) (Paris: Presses Universitaires de France, 1945), 324–328, quotation on 328.

49. For both surveys and detailed studies, see James Knowlson, *Universal Language Schemes in England and France, 1600–1800* (Toronto: University of Toronto Press, 1975); M. M. Slaughter, *Universal Languages and Scientific Taxonomy in the Seventeenth Century* (Cambridge: Cambridge University Press, 1982).

50. On the dissatisfaction with Latin, see Knowlson, *Universal Language Schemes in England and France*, 8; J. A. Large, *The Foreign-Language Barrier: Problems in Scientific Communication* (London: André Deutsch, 1983), 138; Hans Aarsleff, *From Locke to Saussure: Essays on the Study of Language and Intellectual History* (London: Athlone, 1982), 260; and Peter Dear, *Mersenne and the Learning of the Schools* (Ithaca: Cornell University Press, 1988), 170, 229.

51. On the connection of Chinese to the enthusiasm for philosophical languages, see Jonathan Cohen, "On the Project of a Universal Character," *Mind* 63, no. 249 (January 1954): 49–63, on 51; Barbara J. Shapiro, *John Wilkins, 1614–1672: An Intellectual Biography* (Berkeley: University of California Press, 1969), 47; and Knowlson, *Universal Language Schemes in England and France*, 25.

52. Knowlson, *Universal Language Schemes in England and France*, 108–109.

53. Shapiro, *John Wilkins*, 46–47.

54. See especially Clark Emery, "John Wilkins' Universal Language," *Isis* 38, no. 3–4 (February 1948): 174–185; Benjamin DeMott, "The Sources and Development of John Wilkins' Philosophical Language," *Journal of English and Germanic Philology* 57 (1958): 1–13; and the delightful account in Arika Okrent, *In the Land of Invented Languages: Esperanto Rock Stars, Klingon Poets, Loglan Lovers, and the Mad Dreamers Who Tried to Build a Perfect Language* (New York: Spiegel & Grau, 2009), chapter 1.

55. John Wilkins, *An Essay Towards a Real Character, and a Philosophical Language* (London: John Martin, 1668), 10. Emphasis in original.

56. Slaughter, *Universal Languages and Scientific Taxonomy in the Seventeenth Century*, 176; Knowlson, *Universal Language Schemes in England and France*, 140.

57. Parry Moon and Domina Eberle Spencer, "Languages for Science," *Journal of the Franklin Institute* 246, no. 1 (July 1948): 1–12, on 5.

58. See, for example, Robert Boyle's objections to Latin, as described in Richard Jones, "Science and Language in England of the Mid-Seventeenth Century," *Journal of English and Germanic Philology* 31, no. 3 (1932): 315–331, on 319.

59. Galileo was translated into Latin by his friend C. Bernegger and then published in Holland by Elsevier. Jozef IJsewijn and Dirk Sacré, *Companion to Neo-Latin Studies, Part II: Literary, Linguistic, Philological and Editorial Questions*, 2d. ed. (Leuven: Leuven University Press, 1998), 494. Just because Galileo did not want to talk to the rest of Europe does not mean the rest of Europe did not want to hear him.

60. Peter Burke, "Translations into Latin in Early Modern Europe," in Burke and R. Po-Chia Hsia, eds., *Cultural Translation in Early Modern Europe* (Cambridge: Cambridge University Press, 2007): 65–80, on 73–74; Isabelle Pantin, "The Role of Translations in European Scientific Exchanges in the Sixteenth and Seventeenth Centuries," in ibid.: 163–179, on 166, 172.

61. On the Reformation, see Françoise Waquet, *Latin, or the Empire of a Sign: From the Sixteenth to the Twentieth Centuries*, tr. John Howe (London: Verso, 2001 [1998]), 21; Peter Burke, *The Art of Conversation* (Ithaca: Cornell University Press, 1993), 35–39; and IJsewijn, *Companion to Neo-Latin Studies, Part I*, 48. On female readers, see Burke, *The Art of Conversation*, 64.

62. IJsewijn and Sacré, *Companion to Neo-Latin Studies, Part II*, 324.

63. On translation into Latin, see Burke, *The Art of Conversation*, 41–42; idem, "Cultures of Translation in Early Modern Europe," in Burke and Hsia, eds., *Cultural Translation in Early Modern Europe* (2007): 7–38, on 15, 20; Waquet, *Latin, or the Empire of a Sign*, 85; Augustinius Hubertus Laeven, *The "Acta Eruditorum" under the Editorship of Otto Mencke (1644–1707): The History of an International Learned Journal between 1682 and 1707*, tr. Lynne Richards (Amsterdam: APA-Holland University Press, 1990), 51; and W. Leonard Grant, "European Vernacular Works in Latin Translation," *Studies in the Renaissance* 1 (1954): 120–156.

64. Anthony Grafton, *Bring Out Your Dead: The Past as Revelation* (Cambridge, MA: Harvard University Press, 2001), 170–171.

65. Howard Stone, "The French Language in Renaissance Medicine," *Bibliothèque d'Humanisme et Renaissance* 15, no. 3 (1953): 315–346. See also Waquet, *Latin, or the Empire of a Sign*, 81–82, on the transition from Latin to French in the sixteenth century.

66. Jean-Baptiste Du Hamel, *Regiae Scientarum Academiae historia* (Paris: Etienne Michallet, 1698), unpaginated preface. I am grateful to Anita Guerrini for bringing this passage to my attention.

67. The information in this paragraph is drawn from J. R. Partington, *A History of Chemistry*, vol. 3 (London: Macmillan, 1962), 179–180; and Hugo Olsson, "Torbern Bergman, 1735–1784," in Göte Carlid and Johann Nordström, eds., *Torbern Bergman's Foreign Correspondence. Volume One: Letters from Foreigners to Torbern Bergman* (Stockholm: Almqvist & Wiksell, 1965): xi–xviii. For Bergman's own account, see his relatively sparse autobiographical essay, composed shortly before his death: Torbern Bergman, "Självbiografi," in *Äldre svenska biografier*, v. 3–4 (Uppsala: Almqvist & Wiksell, 1916): 83–103.

68. Marco Beretta, *The Enlightenment of Matter: The Definition of Chemistry from Agricola to Lavoisier* (Canton, MA: Science History Publications, 1993), 93, 317; Evan M. Melhado, *Jacob Berzelius: The Emergence of His Chemical System* (Stockholm: Almqvist & Wiksell International, 1981), 63. On eighteenth-century Swedish science in general, see Andreas Önnerfors, "Translation Discourses of the Enlightenment: Transcultural Language Skills and Cross-References in Swedish and German Eighteenth-Century Learned Journals," in Stefanie Stockhorst, ed., *Cultural Transfer through Translation: The Circulation of Enlightened Thought in Europe by Means of Translation* (Amsterdam: Rodopi, 2010): 209–229.

69. Marco Beretta, "T. O. Bergman and the Definition of Chemistry," *Lychnos* (1988): 37–67, on 40.

70. Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, MA: Harvard University Press, 20), chapter 1 (esp. p. 28 on his ignorance of French).

71. Johann Gottlieb Georgi to Bergman, 9 August 1768, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 67.

72. Richard Kirwan to Bergman, 20 January 1783, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 182. This is Kirwan's fifth letter.

73. Franz Xaver Schwediauer to Bergman, 3 July 1780, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 329–330.

74. Fausto de Elhuyar to Bergman, 15 January 1784, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 58.

75. Guyton de Morveau to Bergman, 10 October 1781, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 119; and Editors' introduction, in ibid., xxxv, xxxviii.

76. Franz Xaver Schwediauer to Bergman, 14 February 1874, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 381–382. See also the similar complaint in Ignaz von Born to Bergman, 10 August 1777, reproduced in ibid., 6.

77. Johan Ditlev Breckling Brandt to Bergman, 22 November 1770, reproduced in Carlid and Nordström, *Torbern Bergman's Foreign Correspondence*, 11.

78. For Sweden, see Margareta Benner and Emin Tengström, *On the Interpretation of Learned Neo-Latin: An Explorative Study Based on Some Texts from Sweden (1611–1716)* (Göteborg: Acta Universitatis Gothoburgensis, 1977). On Latin outside the universities, see Isabelle Pantin, "Latin et langues vernaculaires dans la littérature scientifique européenne au début de l'époque moderne (1550–1635)," in Roger Chartier and Pietro Corsi, eds., *Sciences et langues en Europe* (Paris: European Communities, 2000 [1994]): 41–56. For an excellent general picture of Latin's endurance, see Ann Blair, "La persistance du latin comme langue de science à la fin de la Renaissance," in ibid.: 19–39.

79. Alix Cooper, *Inventing the Indigenous: Local Knowledge and Natural History in Early Modern Europe* (Cambridge: Cambridge University Press, 2007), 78–79.

80. On libraries, see Jonathan I. Israel, *Radical Enlightenment: Philosophy and the Making of Modernity 1650–1750* (New York: Oxford University Press, 2001), 137; on Voltaire, see Burke, *The Art of Conversation*, 53.

81. Janson, *A Natural History of Latin*, 159.

82. See the explanation in Beretta, "T. O. Bergman and the Definition of Chemistry," 53–54; and Beretta, *The Enlightenment of Matter*, 102, 148, 155.

83. Torbern Bergman, *Meditationes de systemate fossilium naturali* (Florence: Typis Josephi Tofani, 1784), 123–124. This is the first Italian edition; the work was originally published in *Nova acta Regiae Societatis Scientiarum Upsalensis* 4 (1784): 63–128.

84. Maurice P. Crosland, *Historical Studies in the Language of Chemistry* (Cambridge, MA: Harvard University Press, 1962), 135–136, 164; Beretta, "T. O. Bergman and the Definition of Chemistry," 55; Beretta, *The Enlightenment of Matter*, 139–140, 318.

85. Trevor Williams, "Scientific Literature: Its Influence on Discovery and Progress," *Interdisciplinary Science Reviews* 2, no. 2 (1977): 165–172, on 165.

86. IJsewijn and Sacré, *Companion to Neo-Latin Studies, Part II*, 258–259.

Chapter Two

1. Mendeleev, *Neftianaia promyshlennost' v severo-amerikanskom shtate Pensil'vanii i na Kavkaze* (St. Petersburg: Obshchestvennaia pol'za, 1877), reproduced in D. I. Mendeleev, *Sochineniia*, v. 10: *Neft'* (Moscow: Izd. AN SSSR, 1949), 153.

2. On the creation of the periodic system, see Michael D. Gordin, *A Well-Ordered Thing: Dmitrii I. Mendeleev and the Shadow of the Periodic Table* (New York: Basic Books, 2004), chapter 2, and references therein.

3. D. I. Mendeleev, *Novye materialy po istorii otkrytiia periodicheskogo zakona*, ed. N. A. Figurovskii (Moscow: Izd. AN SSSR, 1950), image 2.

4. For an introduction to these three conflicts, see, respectively, Domenico Bertoloni Meli, *Equivalence and Priority: Newton versus Leibniz* (Oxford: Clarendon Press, 1993); Thomas S. Kuhn, "Energy Conservation as an Example of Simultaneous Discovery," in Kuhn, *The Essential Tension: Selected Studies in Scientific Tradition and Change* (Chicago: University of Chicago Press, 1977): 66–104; and Janet Browne, *Charles Darwin: The Power of Place* (Princeton: Princeton University Press, 2002), chapter 1.

5. See Michael D. Gordin, "The Textbook Case of a Priority Dispute: D. I. Mendeleev, Lothar Meyer, and the Periodic System," in Jessica Riskin and Mario Biagioli, eds., *Nature Engaged: Science in Practice from the Renaissance to the Present* (New York: Palgrave Macmillan, 2012): 59–82.

6. J. W. van Spronsen, *The Periodic System of Chemical Elements: A History of the First Hundred Years* (Amsterdam: Elsevier, 1969), 1, and 142–143.

7. Minutes of the Russian Chemical Society meeting of 6 March 1869 (O.S.), *ZhRFKhO* 1 (1869), 35. In the nineteenth century, the Russian calendar lagged twelve days behind the new-style Gregorian calendar standard in Western Europe.

8. Mendeleev's findings were also reported in German in the flagship journal of the fledging German Chemical Society, but in much briefer form: V. von Richter, "[Correspondence from St. Petersburg]," *Berichte der Deutschen Chemischen Gesellschaft zu Berlin* 2 (1869): 552–554.

9. On Beilstein's relationship with Meyer, see his letter to Jakob Volhard lamenting the death of his friend, on 30 May/11 June 1895, reproduced in Elena Roussanova, *Friedrich Konrad Beilstein, Chemiker zweier Nationen: Sein Leben und Werk sowie einige Aspekte der deutsch-russischen Wissenschaftsbeziehungen in der zweiten Hälfte des 19. Jahrhunderts im Spiegel seines brieflichen Nachlasses*, vol. 2 (Hamburg: Norderstedt, 2007), 429.

10. Lothar Meyer, *Die modernen Theorien der Chemie und ihre Bedeutung für die chemische Statik* (Breslau: Maruschke & Berendt, 1864), 136.

11. Karl Seubert, "Zur Geschichte des periodischen Systems," *Zeitschrift für Anorganische Chemie* 9 (1895): 334–338.

12. D. Mendelejeff, "Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente," *Zeitschrift für Chemie*, N.S. 5 (1869): 405–406, on 405.

13. Lothar Meyer, "Die Natur der chemischen Elemente als Function ihrer Atomgewichte," *Annalen der Chemie und Pharmacie*, Supp. VII (1870): 354–364, on 355–356, 358.

14. Mendeleev, "Sootnoshenie svoistv s atomnym vesom elementov," *ZhRFKhO* 1 (1869): 60–79, on 76, reproduced in Mendeleev, *Periodicheskii zakon. Klassiki nauki*, ed. B. M. Kedrov (Moscow: Izd. AN SSSR, 1958), 30. Emphasis in original.

15. Mendeleev himself would highlight the damage of this translation error in a German article in 1873: D. Mendelejeff, "Zur Frage über das System der Elemente," *Berichte der Deutschen Chemischen Gesellschaft* 4 (1871): 348–352, on 351. This issue has only rarely and all-too-briefly been noted in the massive scholarship on the history of the periodic system, and its implications have never been fully explored. See V. A. Krotikov, "Dve oshibki v pervykh publikatsiiakh o periodicheskom zakone

D. I. Mendeleevym," *Voprosy istorii estestvoznaniia i tekhniki,* no. 4 (29) (1969): 129–131; and Van Spronsen, *The Periodic System of Chemical Elements,* 127.

16. Quoted in K. Bening, *D. I. Mendeleev i L. Meier* (Kazan: Tsentral'naia tip., 1911), ii.

17. Mendeleev, "Ob atomnom ob"eme prostykh tel" (1870), in Mendeleev, *Periodicheskii zakon. Klassiki nauki,* 48–49; and Mendeleev, "O meste tseriia v sisteme elementov" (1870), in ibid., 59.

18. Mendeleev to Erlenmeyer, [August 1871?], in Otto Krätz, "Zwei Briefe Dmitri Iwanowitsch Mendelejeffs an Emil Erlenmeyer," *Physis* 12 (1970): 347–352, on 351.

19. Mendelejeff, "Die periodische Gesetzmässigkeit der chemischen Elemente," reproduced in Mendeleev, *Nauchnyi arkhiv, t. 1. Periodicheskii zakon,* ed. B. M. Kedrov (Moscow: Izd. AN SSSR, 1953), on 361. Emphasis in original.

20. Lothar Meyer, *Die modernen Theorien der Chemie und ihre Bedeutung für die chemische Statik,* 3d. ed. (Breslau: Maruschke & Berendt, 1876), 291n. On the second edition, see idem, *Die modernen Theorien der Chemie und ihre Bedeutung für die chemische Statik,* 2d. ed. (Breslau: Maruschke & Berendt, 1872), 298.

21. Adolphe Wurtz to Mendeleev, 27 July 1877, ADIM I-V-23–1–27.

22. Adolphe Wurtz, *La théorie atomique* (Paris: Librairie Germer Ballière et Cie., 1879), 112. On Meyer, see pages 118 and 122.

23. Adolf Wurtz to German Chemical Society, 29 December 1879, as printed in minutes of the meeting of 11 January 1880, *Berichte der Deutschen Chemischen Gesellschaft* 13 (1880); 6–7, on 7.

24. Adolphe Wurtz to German Chemical Society, 1 March 1880, as printed in *Berichte der Deutschen Chemischen Gesellschaft* 13 (1880): 453–454.

25. Lothar Meyer to the Vorstand of the German Chemical Society, 25 January 1880, as printed in *Berichte der Deutschen Chemischen Gesellschaft* 13 (1880): 220–221, on 221.

26. Lothar Meyer, "Zur Geschichte der periodischen Atomistik [I]," *Berichte der Deutschen Chemischen Gesellschaft* 13 (1880): 259–265, on 261 and 259 ("judge").

27. Mendeleev, "Spisok moikh sochinenii," reproduced in S. A. Shchukarev and S. N. Valk, eds., *Arkhiv D. I. Mendeleeva, t. 1: Avtobiograficheskie materialy, sbornik dokumentov* (Leningrad: Izd. Leningradskogo gosudarstvennogo universiteta imeni A. A. Zhdanova, 1951), 67.

28. D. Mendelejeff, "Zur Geschichte des periodischen Gesetzes," *Berichte der Deutschen Chemischen Gesellschaft* 13 (1880): 1796–1804, on 1799n1, 1800n3, 1797, and 1801.

29. Lothar Meyer, "Zur Geschichte der periodischen Atomistik [II]," *Berichte der Deutschen Chemischen Gesellschaft* 13 (1880): 2043–2044, on 2043. Emphasis in original.

30. Iu. I. Solov'ev, *Istoriia khimii v Rossii: Nauchnye tsentry i osnovnye pravleniia issledovaniia* (Moscow: Nauka, 1985), 79–81.

31. See Nathan M. Brooks, "Russian Chemistry in the 1850s: A Failed Attempt at Institutionalization," *Annals of Science* 52 (1995): 577–589.

32. *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta* 1 (1859), front cover.

33. N. Sokolov and A. Engel'gardt, "Ot redaktsii," *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta* 1 (January 1859): i–xvi, on ix.

34. August Hofmann, "O dvuatomnykh i triatomnykh ammiakakh," *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta* 3 (1860): 55–74; Edward Frankland, Auguste Cahours, and George Buckton, "O metalloorganicheskikh soedineniiakh," *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta* 3 (1860): 109–129.

35. For example, A. M. Butlerov, "O nekotorykh produktakh deistviia al'kogoliata natriia na iodoform," *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta* 3 (1860): 340–351.

36. N. N. Sokolov to Mendeleev, 28 January 1860 (O.S.), St. Petersburg, ADIM I-V-44–1–12.

37. Quoted in Richard Anschütz, *August Kekulé,* 2 v. (Berlin: Verlag Chemie, 1929), I:130. See also the opening editorial in the first issue: A. Kekulé, G. Lewinstein, F. Eisenlohr, and M. Cantor, "[Editorial Announcement]," *Kritische Zeitschrift für Chemie, Physik und Mathematik* 1 (1858): 3–7.

38. Otto Krätz, ed., *Beilstein-Erlenmeyer: Briefe zur Geschichte der chemischen Dokumentation und des chemischen Zeitschriftenwesens* (Munich: Werner Fritsch, 1972), 11.

39. On Erlenmeyer's sense of humor, see Richard Meyer, "Emil Erlenmeyer," *Chemiker-Zeitung* 23, no. 19 (13 February 1909): 161–162, on 161. Intrusive editorializing was not atypical in several of the most prominent scientific journals of the day. On the norms and practices of midcentury chemical publishing, see J. P. Phillips, "Liebig and Kolbe, Critical Editors," *Chymia* 2 (1966): 89–97. For contemporary complaints, see the letter from Kekulé to Erlenmeyer, 8 November 1871, quoted in Anschütz, *August Kekulé,* I:407; and Beilstein to Butlerov, 24 November 1866 (O.S.), reproduced in G. W. Bykow and L. M. Bekassowa, "Beiträge zur Geschichte der Chemie der 60-er Jahre des XIX. Jahrhunderts: II. F. Beilsteins Briefe an A. M. Butlerow," *Physis* 8 (1966): 267–285, on 281.

40. On the Russian contributions to the *Zeitschrift,* and a general history, see G. V. Bykov and Z. I. Sheptunova, "Nemetskii 'Zhurnal khimii' (1858–1871) i russkie khimiki (K istorii khimicheskoi periodiki)," *Trudy Instituta istorii estestvoznaniia i tekhniki* 30 (1960): 97–110. On Russian students in Heidelberg, see Gesa Bock, "Studenten des russischen Reichs an der Universität Heidelberg (1862/63–1914)" (Diplomarbeit, Institüt für Übersetzen und Dolmetschen, Universität Heidelberg, 1991); Willy Birkenmaier, *Das russische Heidelberg: Zur Geschichte der deutsch-russischen Beziehungen im 19. Jahrhundert* (Heidelberg: Wunderhorn, 1995); and Annette Nolte, *D. I. Mendeleev in Heidelberg, Russica Palatina* 22 (1993). On Borodin, see Michael D. Gordin, "The Weekday Chemist: The Training of Aleksandr Borodin," in Jed Z. Buchwald, ed., *A Master of Science History: Essays in Honor of Charles Coulston Gillispie, Archimedes* 30 (Berlin: Springer, 2012): 137–164.

41. Otto Krätz, "Emil Erlenmeyer, 1825–1909," *Chemie in unserer Zeit* 6 (1972): 52–58, on 55; M. Conrad, "Emil Erlenmeyer," *Berichte der Deutschen Chemischen Gesellschaft* 43 (1910): 3645–3664, on 3647.

42. Beilstein to Butlerov, 24 November 1866 (O.S.), reproduced in Bykow and Bekassowa, "Beiträge zur Geschichte," 281. On postal and ordering issues, see Beilstein to Butlerov, 29/17 January 1865, reproduced in ibid., 270; and V. V. Markovnikov to A. M. Butlerov, 10 December [1867, O.S.], reproduced in G. V. Bykov, ed., *Pis'ma russkikh khimikov k A. M. Butlerovu, Nauchnoe Nasledstvo,* v. 4 (Moscow: Izd. AN SSSR, 1961), 248. See also the discussion in Alan J. Rocke, *The Quiet Revolution: Hermann Kolbe and the Science of Organic Chemistry* (Berkeley: University of California Press, 1993), 255, 258.

43. Erlenmeyer to Butlerov, 25 March 1864, reproduced in G. W. Bykow and L. M. Bekassowa, "Beiträge zur Geschichte der Chemie der 60-er Jahre des XIX. Jahrhunderts: I. Briefwechsel zwischen E. Erlenmeyer und A. M. Butlerow (von 1862 bis 1876)," *Physis* 8 (1966): 185–198, on 190–191.

44. On Beilstein's biography, see Michael D. Gordin, "Beilstein Unbound: The Pedagogical Unraveling of a Man and His *Handbuch*," in David Kaiser, ed., *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives* (Cambridge, MA: MIT Press, 2005): 11–39.

45. Krätz, *Beilstein-Erlenmeyer*, 7.

46. Beilstein to Kekulé, 3 November 1865, quoted in Friedrich Richter, "K. F. Beilstein, sein Werk und seine Zeit: Zur Erinnerung an die 100. Wiederkehr seines Geburtstages," *Berichte der Deutschen Chemischen Gesellschaft* 71A (1938): 35–71, on 42. Emphasis in original.

47. Beilstein to Butlerov, 18/6 November 1866, reproduced in Bykow and Bekassowa, "Beiträge zur Geschichte der Chemie . . . II," 279.

48. Beilstein to Butlerov, 29/17 January 1865, reproduced in Bykow and Bekassowa, "Beiträge zur Geschichte der Chemie . . . II," 271. Emphasis in original.

49. Friedrich Beilstein, "O rabotakh chlenov Russkago fiziko-khimicheskago obshchestva po aromaticheskomu riadu," in *Russkoe khimicheskoe obshchestvo. XXV (1868–1893). Otdelenie khimii Russkago fiziko-khimicheskago obshchestva* (St. Petersburg: V. Demakov, 1894), 39–56, on 48; Beilstein, signed footnote in A. Engelhardt, "Ueber die Einwirkung der wasserfreien Schwefelsäure auf einige organische Verbindungen," *Zeitschrift für Chemie und Pharmacie* 7 (1864): 42–46 and 85–87, on 42n2.

50. Beilstein comment on D. Mendelejeff, "Ueber die Verbindung des Weingeistes mit Wasser," *Zeitschrift für Chemie*, N.S. 1 (1865): 257–264, on 264.

51. Beilstein to Erlenmeyer, 26/14 April 1871, reproduced in Krätz, *Beilstein-Erlenmeyer*, 16. See also Rudolph Fittig to Erlenmeyer, 2 January 1872, Tübingen, HBA.

52. Quoted in V. V. Kozlov and A. I. Lazarev, "Tri chetverti veka Russkogo Khimicheskogo Obshchestva (1869–1944)," in S. I. Vol'fkovich and V. S. Kiselev, eds., *75 let periodicheskogo zakona D. I. Mendeleeva i Russkogo Khimicheskogo Obshchestva* (Moscow: Izd. AN SSSR, 1947): 115–265, on 128.

53. N. A. Menshutkin and G. Shmidt, "Otchet o deiatel'nosti Russkago khimicheskago obshchestva v 1869 g.," *ZhRFKhO* 2 (1870): 3–6, on 5.

54. Minutes of Russian Chemical Society meeting of 4 March 1871 (O.S.), *ZhRFKhO* 3 (1871), 93.

55. V. V. Markovnikov to A. M. Butlerov, 9 October 1874 (O.S.), reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 272.

56. Minutes of Russian Chemical Society meeting of 3 April 1880 (O.S.), *ZhRFKhO* 12 (1880): 182–183.

57. Beilstein to Erlenmeyer, 23 September/5 October 1873, reproduced in Krätz, *Beilstein-Erlenmeyer*, 41.

58. A. N. Popov to A. M. Butlerov, 30 December 1871 (O.S.), reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 340.

59. V. V. Markovnikov to A. M. Butlerov, 13 January [1870] (O.S.), reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 259; M. D. L'vov to A. M. Butlerov, 22 July 1873 (O.S.), reproduced in ibid., 200.

60. V. V. Markovnikov to A. M. Butlerov, 17 January [1868] (O.S.), reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 252.

61. Beilstein to Erlenmeyer, 29 April/11 May 1872, reproduced in Krätz, *Beilstein-Erlenmeyer*, 26. Emphasis in original.

62. Draft of Erlenmeyer to Beilstein, 19 May 1872, reproduced in Krätz, *Beilstein-Erlenmeyer*, 33–34.

63. Johanna Meyer (née Volkmann) and her children, Tübingen, 12 April 1895, ADIM I-V-27-1-26.

64. Lothar Meyer, ed., *Die Anfänge des Systems der chemischen Elemente: Abhandlungen von J. W. Doebereiner 1829 und Max Pettenkofer 1850 nebst einer geschichtlichen Uebersicht der Weiterentwicklung der Lehre von den Triaden der Elemente* (Leipzig: W. Engelmann, 1895).

65. Lothar Meyer to Mendeleev, 16 August 1893, Tübingen, ADIM I-V-63-1-70.

66. Karl Seubert, ed., *Das natürliche System der chemischen Elemente: Abhandlungen von Lothar Meyer 1864–1869 und D. Mendelejeff 1869–1871* (Leipzig: W. Engelmann, 1895). The date span in the title represents a subtle priority claim in itself.

67. http://royalsociety.org/Content.aspx?id=3277. (Accessed 20 August 2012.)

68. Editorial comments in Seubert, ed., *Das natürliche System der chemischen Elemente*, 122–123. See also Nikolai A. Menshutkin, *Ocherk razvitiia khimicheskikh vozzrenii* (St. Petersburg: V. Demakov, 1888), 319.

69. Menshutkin in minutes of Russian Chemical Society meeting of 13 April 1895 (O.S.), *ZhRFKhO* 27 (1895): 197; and Butlerov, "Istoricheskii ocherk razvitiia khimii v poslednie 40 let," stenograph of lectures from 1879–1880, reproduced in Butlerov, *Sochineniia*, 3 v. (Moscow: AN SSSR, 1953–1958), III: 280.

70. P. Phillips Bedson, "Lothar Meyer Memorial Lecture," *Journal of the Chemical Society* 69 (1896): 1403–1439, on 1409.

71. See, for example, F. P. Venable, *The Development of the Periodic Law* (Easton, PA: Chemical Publishing Co., 1896), 95.

72. Minutes of Russian Chemical Society meeting of 3 April 1875 (O.S.), *ZhRFKhO* 7 (1875): 177.

73. In *Russkoe khimicheskoe obshchestvo*, 4.

74. In *Russkoe khimicheskoe obshchestvo*, 2.

75. D. Mendeléeff, "Comment j'ai trouvé le système périodique des éléments," *Revue générale de chimie pure et appliquée* 4 (1901): 533–546, on 546.

76. V. I. Modestov, *Russkaia nauka v posledniia dvadtsat' piat' let* (Odessa: Ekonomicheskaia tip., 1890), 9. Emphasis in original.

Chapter Three

1. F. M. Dostoevskii, *Polnoe sobranie sochinenii v tridtsati tomakh*, 30 v. (Leningrad: Nauka, 1972–1990), XXI: 121.

2. As of 1971, Russian speakers numbered just under half of all Slavic speakers. G. S. Vinokur, *The Russian Language: A Brief History*, tr. Mary A. Forsyth (Cambridge: Cambridge University Press, 1971), 1. That proportion is almost certainly higher today.

3. Vinokur, *The Russian Language*, 1.

4. W. K. Matthews, *The Structure and Development of Russian* (Cambridge: Cambridge University Press, 1953), 111.

5. Vinokur, *The Russian Language*, 22–23, quotation on 23. See also Lawrence L. Thomas, introduction to V. V. Vinogradov, *The History of the Russian Literary Language from the Seventeenth Century to the Nineteenth*, tr. and ed. Lawrence L. Thomas (Madison: University of Wisconsin Press, 1969), xii.

6. B. O. Unbegaun, "Colloquial and Literary Russian," *Oxford Slavonic Papers* 1 (1950): 26–36, on 26–27.

7. Vinokur, *The Russian Language*, 32.

8. Matthews, *The Structure and Development of Russian*, 14.

9. Vinokur, *The Russian Language*, 71; Matthews, *The Structure and Development of Russian*, 140.

10. W. K. Matthews, *Russian Historical Grammar* (London: Athlone Press, 1960), 63; Vinogradov, *The History of the Russian Literary Language*, 13–14.

11. Gerta Hüttl Worth, *Foreign Words in Russian: A Historical Sketch, 1550–1800* (Berkeley: University of California Press, 1963), 1–2.

12. Vinogradov, *The History of the Russian Literary Language*, 33. For a magisterial survey of transformations of Russian in this period, see V. M. Zhivov, *Iazyk i kul'tura v Rossii XVIII veka* (Moscow: Shkola "Iazyki russkoi kul'tury," 1996).

13. Unbegaun, "Colloquial and Literary Russian," 29; Vinogradov, *The History of the Russian Literary Language*, 31. On the context of Peter's translation movement, see Matthews, *The Structure and Development of Russian*, 156; and Dennis Ward, *The Russian Language Today: System and Anomaly* (London: Hutchinson University Library, 1965), 114.

14. Christopher D. Buck, "The Russian Language Question in the Imperial Academy of Sciences, 1724–1770," in Riccardo Picchio and Harvey Goldblatt, eds., *Aspects of the Slavic Language Question*, 2 vol. (New Haven: Yale Concilium on International and Area Studies, 1984), II: 187–233, on 188–189, 194.

15. Buck, "The Russian Language Question in the Imperial Academy of Sciences," 198–199.

16. Hans Rogger, *National Consciousness in Eighteenth-Century Russia* (Cambridge, MA: Harvard University Press, 1960), 109.

17. E. Lenz to council of St. Petersburg University, 10 October 1859 (O.S.), TsGIASPb, f. 14, op. 1, d. 6039, l. 1.

18. On Lomonosov's *Rossiiskaia grammatika* (1755) and *O pol'ze knig tserkovnykh v Rossiiskom iazyke* (1758) and their influence on Russian stylistics, see Vinokur, *The Russian Language*, 101; Unbegaun, "Colloquial and Literary Russian," 30; and Vinogradov, *The History of the Russian Literary Language*, 72–73. On French as a template for later Russian syntax, see ibid., 66.

19. Vinogradov, *The History of the Russian Literary Language*, 243.

20. On the history of the German language in Russia, see Alfons Höcherl, "Kulturelle und wissenschaftliche deutsche Einflüsse in Russland im historischen Überblick," in Ulrich Ammon and Dirk Kemper, eds., *Die deutsche Sprache in Russland: Geschichte, Gegenwart, Zukunftsperspektiven* (Munich: Iudicium, 2011), 23–40.

21. Edv. Hjelt, "Friedrich Konrad Beilstein," *Berichte der Deutschen Chemischen Gesellschaft* 40 (1907): 5041–5078, on 5069.

22. Petition to the Vice-President of the Academy of Sciences, 9 October 1854 (O.S.), PFARAN f. 5, op. 1(1854), d. 513, l. 2.

23. K. K. Klaus to A. M. Butlerov, 15 April 1853 (O.S.), reproduced in G. V. Bykov, ed., *Pis'ma russkikh khimikov k A. M. Butlerovu, Nauchnoe nasledstvo*, v. 4 (Moscow: Izd. AN SSSR, 1961), 161.

24. Klaus to Butlerov, 12 May 1857 (O.S.), reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 166.

25. Klaus to Butlerov, 11 August 1853 (O.S.), reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 164.

26. A. A. Inostrantsev, *Vospominaniia (Avtobiografiia)*, eds. V. A. Prozorovskii and I. L. Tikhonov (St. Petersburg: Peterburgskoe vostokovedenie, 1998), 95.

27. Borodin to M. A. Balakirev, [22–30 January 1867, O.S.], reproduced in A. P. Borodin, *Pis'ma: Polnoe sobranie, kriticheski sverennoe s podlinnymi tekstami*, 4 v., ed. S. A. Dianin (Moscow: Gos. muzykal'nyoe izd., 1927–1950), I: 94.

28. Minutes of the Russian Chemical Society meeting of 12 September 1902 (O.S.), *ZhRFKhO* 34 (1902): 637.

29. I. M. Sechenov, *Avtobiograficheskie zapiski* (Moscow: Izd. AN SSSR, 1945), 1011.

30. Kablukov's autobiography, PFARAN, f. 474, op. 1, d. 201, quoted in Iu. I. Solov'ev, M. I. Kablukova, and E. V. Kolesnikov, *Ivan Alekseevich Kablukov* (Moscow: Izd. AN SSSR, 1957), 20–22.

31. V. V. Markovnikov to A. M. Butlerov, 22 July/3 August [1865], reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 215.

32. Markovnikov to Butlerov, 7 August [1865], reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 216.

33. A. Bulginskii to Emil Erlenmeyer, 29 October 1866, HBA.

34. Mendeleev's library is described in R. B. Dobrotin and N. G. Karpilo, *Biblioteka D. I. Mendeleeva* (Leningrad: Nauka, 1980).

35. See Mendeleev's diary entries of 1 and 6 January 1861, reproduced in D. I. Mendeleev, "Dnevnik 1861 g.," *Nauchnoe nasledstvo* 2 (1951): 111–212, on 112 and 114.

36. Letter of 25 November 1886 (O.S.), quoted in Iu. I. Solov'ev, *Istoriia khimii v Rossii: Nauchnye tsentry i osnovnye pravleniia issledovaniia* (Moscow: Nauka, 1985), 355.

37. Mendeleev to Kekulé, 28 June/10 July 1883, Boblovo, quoted in Richard Anschütz, *August Kekulé*, 2 v. (Berlin: Verlag Chemie, 1929), I: 692, 694.

38. Mendeleev to Erlenmeyer, 24 August/3 September [1870?], in Otto Krätz, "Zwei Briefe Dmitri Iwanowitsch Mendelejeffs an Emil Erlenmeyer," *Physis* 12 (1970): 347–352, on 350.

39. Mendeleev, *Dva londonskikh chteniia*, reproduced in Mendeleev, *Izbrannye sochineniia*, v. 2. (Leningrad: ONTI, 1934), 342.

40. Mendeleev to Menshutkin, 23 July 1889, Boblovo, reproduced in B. N. Menshutkin, *Zhizn' i deiatel'nost' Nikolaia Aleksandrovicha Menshutkina* (St. Petersburg: M. Frolova, 1908), 109.

41. Crum Brown to Mendeleev, 29 March 1884, reproduced in V. E. Tishchenko and M. N. Mladentsev, *Dmitrii Ivanovich Mendeleev, ego zhizn' i deiatel'nost': Universitetskii period, 1861–1890 gg., Nauchnoe nasledstvo*, v. 21 (Moscow: Nauka, 1993), 117. Presumably, this letter was originally written in German, but I was only able to find it in Russian translation.

42. William Ramsay to Mendeleev, 22 September 1889, ADIM Alb. 2/280.

43. William Ramsay to Mendeleev, undated, ADIM Alb. 2/201.

44. William Ramsay to Mendeleev, 6 January 1892, ADIM Alb. 3/500.

45. William Ramsay to Mendeleev, 20 January 1892, ADIM Alb. 3/501.

46. Minutes of the Russian Chemical Society meeting of 5 November 1870 (O.S.), *ZhRFKhO* 2 (1870), 290ni.

47. Otto Jespersen, "Nature and Art in Language," *American Speech* 5 (1929): 89–103, on 90–91. On similar layering in Russian chemical nomenclature, see David Kraus, "Sources of Scientific Russian," *Slavic and East European Journal* 5, no. 2 (Summer 1961): 123–131, on 128–129.

48. Viktor A. Kritsman, "Die Entstehung der russischen chemischen Nomenklatur im europäischen Kontext: Die Frühgeschichte," in Bernhard Fritscher and Gerhard Brey, eds., *Cosmographica et Geographica: Festschrift für Heribert M. Nobis zum 70. Geburtstag* (Munich: Institut für Geschichte der Naturwissenschaften, 1994): 199–218, on 18; Victor A. Kritsman and Briggite Hoppe, "The Study of Lavoisier's Works by Russian Scientists," *Revue d'histoire des sciences* 48 (1995): 133–142, esp. 135–136; Solov'ev, *Istoriia khimii v Rossii*, 58–60; Nikolai A. Menshutkin, *Ocherk razvitiia khimicheskikh vozzrenii* (St. Petersburg: V. Demakov, 1888), 31ni.

49. F. Savchenkov, "Istoricheskie materialy po russkoi khimicheskoi nomenklature," *ZhRFKhO* 2 (1870): 205–212, on 205.

50. Iakov D. Zakharov, "Razsuzhdenie o rossiiskom khimicheskom slovoznachenii," *Umozritel'nyia izsledovaniia Imperatorskoi Sanktpeterburgskoi Akademii nauk* 2 (1810): 332–354, on 332–333.

51. M. F. Solov'ev, S. Ia. Nechaev, P. G. Sobolevskii, and G. I. Gess, "Kratkii obzor khimicheskago imenosloviia," *Gornyi zhurnal* 2, no. 6 (1836): 457–463, on 457.

52. Frankland to Kolbe, 3 December 1871, reproduced in Rita Meyer, "Emil Erlenmeyer (1825–1909) als Chemietheoretiker und sein Beitrag zur Entwicklung der Strukturchemie" (Dissertation, Medical Faculty of Ludwig-Maximilians-Universität in Munich, 1984), on 344–345.

53. On the tortured history of the Geneva nomenclature, see the dissertation in progress by Evan Hepler-Smith at Princeton University, entitled "Nominally Rational: Systematic Nomenclature and the Structure of Organic Chemistry, 1889–1940."

54. See Michael D. Gordin, "Beilstein Unbound: The Pedagogical Unraveling of a Man and His *Handbuch*," in David Kaiser, ed., *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives* (Cambridge, MA: MIT Press, 2005): 11–39.

55. Minutes of the Russian Chemical Society meeting of 8 October 1892 (O.S.), *ZhRFKhO* 24 (1892): 542–544. See also Beilstein's early comments on the Geneva nomenclature and Menshutkin's discussion of translations of the French rules into Russian: Minutes of the Russian Chemical Society meeting of 13 September 1890 (O.S.), *ZhRFKhO* 22 (1890): 480; and N. Menshutkin, "K voprosu o khimicheskoi nomenklature: Sostavlenie nazvanii organicheskikh kislot," *ZhRFKhO* 25 (1893): 10.

56. Solov'ev, *Istoriia khimii v Rossii*, 82, 86.

57. K. Ia. Parmenov, *Khimiia kak uchebnyi predmet v dorevoliutsionnoi i sovetskoi shkole* (Moscow: Akademiia pedagogicheskikh nauk RSFSR, 1963), 30.

58. C. G. Lehmann, *Handbuch der physiologischen Chemie* (Leipzig: W. Engelmann, 1854); Justus von Liebig, *Die organische Chemie in ihrer Anwendung auf Physiologie und Pathologie* (Braunschweig: F. Vieweg und Sohn, 1842).

59. On the issue of credit, see Alan J. Rocke, "Kekulé, Butlerov, and the Historiography of the Theory of Chemical Structure," *British Journal for the History of Science* 14 (1981): 27–57.

60. Much of the information in this section on the composition of the textbook is derived from G. V. Bykov, "Materialy k istorii trekh pervykh izdanii 'Vvedeniia k polnomu izucheniiu organicheskoi khimii' A. M. Butlerova," *Trudy Instituta istorii estestvoznaniia i tekhniki* 6 (1955): 243–291.

61. Karl Schmidt to A. M. Butlerov, 1/13 April 1865, reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 402. Emphasis in original.

62. Wurtz to Butlerov, 5 October 1864, reproduced in G. V. Bykov and J. Jacques, "Deux pionniers de la chimie moderne, Adolphe Wurtz et Alexandre M. Boutlerov, d'après une correspondance inédite," *Revue d'historie des sciences* 13 (1960): 115–134, on 126.

63. Markovnikov to Butlerov, 22 July/3 August [1865], reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 216.

64. P. P. Alekseev to Butlerov, 9 January 1867, reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 19.

65. Butlerov to Erlenmeyer, 23 July/4 August 1864, reproduced in G. W. Bykow and L. M. Bekassowa, "Beiträge zur Geschichte der Chemie der 60-er Jahre des XIX. Jahrhunderts: I. Briefwechsel zwischen E. Erlenmeyer und A. M. Butlerow (von 1862 bis 1876)," *Physis* 8 (1966): 185–198, on 193.

66. N. A. Golovkinskii to Butlerov, 11 March 1864, reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 97.

67. On Beilstein's assistance with many stages of the process, see Beilstein to Butlerov, 15/27 October 1867, reproduced in Elena Roussanova, *Friedrich Konrad Beilstein, Chemiker zweier Nationen: Sein Leben und Werk sowie einige Aspekte der deutsch-russischen Wissenschaftsbeziehungen in der zweiten Hälfte des 19. Jahrhunderts im Spiegel seines brieflichen Nachlasses*, vol. 2 (Hamburg: Norderstedt, 2007), 236.

68. Markovnikov to Butlerov, 15/27 January [1867], reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 240.

69. Beilstein to Erlenmeyer, 27 March 1861, reproduced in Roussanova, *Friedrich Konrad Beilstein*, 85. See also Beilstein to Erlenmeyer, 10 November 1861, reproduced in ibid., 78.

70. Freidrich Beilstein, review of D. Mendelejeff's *Organische Chemie*, *Zeitschrift für Chemie und Pharmacie* 5 (1862): 271–276, on 271.

71. Butlerov, *Vvedenie k polnomu izucheniiu organicheskoi khimii*, in Butlerov, *Sochineniia*, II: 12.

72. Paul Walden, "Ocherk istorii khimii v Rossii," in A. Ladenburg, *Lektsii po istorii razvitiia khimii do nashego vremeni*, tr. from 4th ed. by E. S. El'chaninov (Odessa: Mathesis, 1917): 361–654, on 421.

73. Markovnikov, "Sovremennaia khimiia i russkaia khimicheskaia promyshlennost'" (1879), in Markovnikov, *Izbrannye trudy*, ed. A. F. Plate and G. V. Bykov (Moscow: Izd. AN SSSR, 1955), 648. See also idem, "Moskovskaia rech' o Butlerove," ed. Iu. S. Musabekov, *Trudy Instituta istorii estestvoznaniia i tekhniki* 12 (1956): 135–181, on 161.

Chapter Four

1. From L. Zamenhof, ed., *Fundamenta Krestomatio de la lingvo Esperanto*, 18th ed. (Rotterdam: Universala Esperanto-Asocio, 1992 [1903]), 181.

2. Roland G. Kent, "The Scientist and an International Language," *Proceedings of the American Philosophical Society* 63 (1924): 162–170, on 163. Kent advocated the revival of Latin.

3. Luther H. Dyer, *The Problem of an International Auxiliary Language and Its Solution in Ido* (London: Putnam, 1923), 6–7.

4. Leopold Pfaundler, "The Need for a Common Scientific Language," in L. Couturat, O. Jespersen, R. Lorenz, W. Ostwald, and L. Pfaundler, *International Language and Science: Considerations on the Introduction of an International Language into Science*, tr. F. G. Donnan (London: Constable & Company, 1910): 1–10, on 2.

5. L. Couturat and L. Leau, *Histoire de la Langue Universelle* (Paris: Librairie Hachette, 1903), ix.

6. Louis Couturat, *A Plea for an International Language* (London: George J. Henderson, 1905), 8.

7. Otto Jespersen, *An International Language* (London: George Allen & Unwin, 1928), 14.

8. "Stated Meeting, January 6, 1888," *Proceedings of the American Philosophical Society* 25, no. 127 (1888): 1–18, on 4.

9. Jespersen, "Nature and Art in Language," *American Speech* 5 (1929): 89–103, on 89.

10. Detlev Blanke, "The Term 'Planned Language,'" in Humphrey Tonkin, ed., *Esperanto, Interlinguistics, and Planned Language* (Lanham, MD: University Press of America, 1997): 1–20; and Alicja Sakaguchi, "Towards a Clarification of the Function and Status of International Planned Languages," in Ulrich Ammon, ed., *Status and Function of Languages and Language Varieties* (Berlin: Walter de Gruyter, 1989): 399–440. This terminology originated in a scholarly monograph dedicated to standardizing technological nomenclature: Eugen Wüster, *Internationale Sprachnormung in der Technik, besonders in der Elektrotechnik (Die nationale Sprachnormung und ihre Verallgemeinerung)*, 2d ed. (Bonn: H. Bouvier u. Co. Verlag, 1966).

11. Louis Couturat, "Sur la langue internationale," *Revue des questions scientifiques* 52 (1902): 213–223.

12. Louis Couturat, "Autour d'une Langue internationale," *La Revue* 87 (1910): 381–385, on 382.

13. W. A. Oldfather, "Latin as an International Language," *Classical Journal* 16 (1921): 195–206.

14. Albert Léon Guérard, *A Short History of the International Language Movement* (London: T. Fisher Unwin, 1922), 169.

15. Giuseppe Peano, "De Latino sine flexione: Lingua auxiliare internationale," *Revista de mathematica* 8 (1903): 74–83, on 74. Peano even replicated, in his own language, a statement highly reminiscent of the Babel-rousers quoted at the beginning of this chapter: "Conoscentia de tres aut quatuor lingua principale suffice ut nos lege, in originale aut in versione omne libro jam celebre. Sed hodie Russo, Polacco, Rumeno, Japonico, . . . publica in suo lingua libro originale, et non solo libro scholastico" (p. 79). Ellipses in original.

16. M. Monnerot-Dumain, *Précis d'interlinguistique générale et spéciale* (Paris: Librairie Maloine, 1960), 512.

17. Couturat and Leau, *Histoire de la Langue Universelle*, 37. For more on Solresol, see Andrew Large, *The Artificial Language Movement* (Oxford: Basil Blackwell, 1985), 63.

18. Richard Lorenz, "The Relationship of the International Language to Science," in L. Couturat et al., *International Language and Science* (1910): 53–60, on 57.

19. Jespersen, *An International Language*, 27.

20. Karl Brugmann and August Leskien, *Zur Kritik der künstlichen Weltsprachen* (Straßburg: Karl J. Trübner, 1907), 19. For a response to this pamphlet from a linguist, see J. Baudouin de Courtenay, *Zur Kritik der künstlichen Weltsprachen* (Leipzig: Verlag von Veit, 1908).

21. Andrew Drummond, *A Hand-Book of Volapük: And an Elementary Manual of its Grammar and Vocabulary, Prepared from the Gathered Papers of Gemmell Hunter Ibidem Justice, together with an Account of Events Relating to the Annual General Meeting of 1891 of the Edinburgh Society for the Propagation of a Universal Language: Edited for the First Time by Dr. Charles Cordiner* (Edinburgh: Polygon, 2006). Today the term "volapuk" also refers to using Latin characters and Arabic numerals to render Cyrillic letters through their resemblances, so that ш would be written w, and б by the number 6. This was once quite common in text messaging, and is unrelated to the language discussed here.

22. Johann Martin Schleyer, *Volapük (Weltsprache): Grammatik der Universalsprache für alle gebildete Erdbewohner*, 4th. ed. (Überlingen am Bodensee: August Feyel, 1884), iii. Ellipses in original.

23. For example: Schleyer, *Grammar with Vocabularies of Volapük (The Language of the World) for all Speakers of the English Language*, 2d. rev. ed., tr. W. A. Seret (Glasgow: Thomas Murray & Son, 1887); and G. Krause, *The Volapük Commercial Correspondent* (London: Swan Sonnenschein & Co., 1889).

24. Frederick Bodmer, *The Loom of Language* (New York: W. W. Norton, 1944), 460; Couturat and Leau, *Histoire de la Langue Universelle*, 141. For more on Volapük's success in Paris, see Natasha Staller, "Babel: Hermetic Languages, Universal Languages, and Anti-Languages in Fin de Siècle Parisian Culture," *Art Bulletin* 76 (1994): 331–354.

25. Guérard, *A Short History of the International Language Movement*, 103n.

26. Constitution of the Volapükaklub Nolümelopik, [1890?], Volapük Exhibit, APSL.

27. Quoted in Guérard, *A Short History of the International Language Movement*, 98.

28. Alfred Kirchhoff, *Volapük, or Universal Language: A Short Grammatical Course*, 3d ed. (London: Swan Sonnenschein & Co., 1888), 25.

29. This point is emphasized in Guérard, *A Short History of the International Language Movement*, 105.

30. Couturat and Leau, *Histoire de la Langue Universelle*, 142; Guérard, *A Short History of the International Language Movement*, 97; Peter G. Forster, *The Esperanto Movement* (The Hague: Mouton, 1982), 46–47.

31. Large, *The Artificial Language Movement*, 69–70.

32. Guérard, *A Short History of the International Language Movement*, 103.

33. Quoted in Monnerot-Dumaine, *Précis d'interlinguistique générale et spéciale*, 88–90.

34. Ludwig Zamponi, *Zur Frage der Einführung einer internationalen Verkehrssprache* (Graz: Leykam, 1904); Arie De Jong, *Wörterbuch der Weltsprache: Vödabuk Volapüka pro Deutänapükans* (Leiden: E. J. Brill, 1931); and idem, *Gramat Volapüka: Dabükot Balid Pelautöl Nämätü e Zepü Kadäm Volapüka* (Leiden: E. J. Brill, 1931). For Wikipedia, see: http://vo.wikipedia.org/wiki/Cifapad. Ironically, most Volapükology and preservation of fragile and rare materials in the language takes place today through the medium of Esperanto. See Bernard Golden, "Conservation of the Heritage of Volapük," in Tonkin, ed., *Esperanto, Interlinguistics, and Planned Language* (1997): 183–189.

35. "Stated Meeting, January 6, 1888," 10, 12, 16. This report had a large impact on L. L. Zamenhof himself. See Edmond Privat, *Historio de la Lingvo Esperanto*, vol. 1: *Deveno kaj Komenco, 1887–1900* (Leipzig: Ferdinand Hirt & Sohn, 1923), 38.

36. Lawrence A. Sharpe, "Language Projects," *South Atlantic Bulletin* 27 (1961): 1–6, on 4.

37. For his own account, see L. L. Zamenhof, *The Birth of Esperanto: Extract of a Private Letter of Dr. L. L. Zamenhof to N. Borovko*, tr. Henry W. Hetzel (Fort Lee, NJ: Esperanto Association of North America, [1931]). For biographies, see René Centassi and Henri Masson, *L'homme qui a défié Babel: Ludwik Lejzer Zamenhof* (Paris: Éditions Ramsay, 1995); Marjorie Boulton, *Zamenhof: Creator of Esperanto* (London: Routledge and Kegan Paul, 1960); and Edmond Privat, *The Life of Zamenhof*, tr. Ralph Eliott (Oakville, ON: Esperanto Press, 1963 [1920]).

38. Privat, *Life of Zamenhof*, 48–49.

39. Privat, *Historio de la Lingvo Esperanto*, I: 43; Forster, *The Esperanto Movement*, 57.

40. Centassi and Masson, *L'homme qui a défié Babel*, 219; E. Drezen, *Historio de la Mondolinguo: Tra Jarcentoj da Serĉado*, 2d ed., tr. N. Hohlov and N. Nekrasov (Leipzig: Ekrelo, 1931), 181. Exact numbers are quite difficult to calculate due to the unsystematic quality of statistics collection by Esperanto organizations, as discussed in Forster, *The Esperanto Movement*, 18.

41. Boulton, *Zamenhof*, 62. The same kinds of criticisms of de Beaufront can be found in Centassi and Masson, *L'homme qui a défié Babel*, 211; and Privat, *Life of Zamenhof*, 85.

42. W. J. Clark, *International Language: Past, Present & Future* (London: J. M. Dent, 1907), 109. Even the great Esperantist Edmond Privat, who despised the man, gave de Beaufront credit for his propagation of Esperanto in France: Privat, *Historio de la Lingvo Esperanto*, I: 63.

43. Privat, *Historio de la Lingvo Esperanto*, I: 59n1.

44. Boulton, *Zamenhof*, 60; Privat, *Historio de la Lingvo Esperanto*, I: 59.

45. Forster, *The Esperanto Movement*, 75–76.

46. Zamenhof's views on these matters can be found in all the biographies and also Lazare Louis Zamenhof, *Le Hillélisme: Projet de solution de la question juive*, tr. Pierre Janton (Clermont-Ferrand: Association des publications de la Faculté des Lettres et Sciences Humaines, 1995). On neutrality, whereby "toutes les questions religieuses, politiques et sociales seraient rigoureusement exclues des séances publiques du Congrès," see L. Couturat and L. Leau, *Les Nouvelles Langues Internationales: Suite à L'histoire de la Langue Universelle* (Paris: M. L. Couturat, [1907]), 40.

47. Quoted in Forster, *The Esperanto Movement*, 90.

48. Dr. Esperanto [L. L. Zamenhof], *Mezhdunarodnyi iazyk: Predislovie i polnyi uchebnik* (Warsaw: Kh. Kel'ter, 1887), 28.

49. Zamenhof, *Mezhdunarodnyi iazyk*, 29.

50. Forster, *The Esperanto Movement*, 62.

51. Lorenz, "The Relationship of the International Language to Science," 53.

52. R. Mehmke, "Nüns Gletavik (Fovot 2id)," *Nunel Valemik*, no. 2 (1889). Lorenz cited translations of Miess's *Craniology* and Winkler's *Petrification of Fishes*, but I have not been able to track these down. See Lorenz, "The Relationship of the International Language to Science," 54.

53. Zamenhof, *Mezhdunarodnyi iazyk*, 4–5.

54. Editors of *Internacia Scienca Revuo*, "Nia celo," *Internacia Scienca Revuo* 1, no. 1 (January 1904): 1.

55. Iv. Chetverikov to Mendeleev, 30 November 1904, ADIM II-V-24-Ch. The translation appeared as D. Mendelejev, "Provo de kemia kompreno de l'monda etero," tr. Iĉet-Verikov, *Internacia Scienca Revuo* 1, no. 6 (June 1904): 161–167; no. 7 (July 1904): 202–208; no. 8 (August 1904): 225–231. For more on Mendeleev's ether project, see Michael D. Gordin, *A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table* (New York: Basic Books, 2004), chapter 8.

56. Paul Fruictier, "Unu jaro," *Internacia Scienca Revuo* 2, no. 13 (January 1905): 1–4, on 1.

57. Karl F. Kellerman, "The Advance of International Language," *Science* N.S. 30, no. 780 (10 December 1909): 843–844.

58. Clark, *International Language*, 111.

59. R. van Melckebeke and Th. Renard, "Projekto de kemia nomaro esperanta," *Internacia Scienca Revuo* 1, no. 1 (January 1904): 22–25, on 22.

60. Melckebeke and Renard, "Projekto de kemia nomaro esperanta," 23.

61. In "Korespondado," *Internacia Scienca Revuo* 1, no. 3 (March 1904): 92–95, on 92.

62. In "Korespondado," (March 1904), 93.

63. In "Korespondado," *Internacia Scienca Revuo* 1, no. 4 (April 1904): 123–128, on 123.

64. In "Korespondado," (April 1904), 125.

65. In "Korespondado," *Internacia Scienca Revuo* 1, no. 5 (May 1904): 156–158, on 156.

66. Amiko, "Terminaro de l'neorganika kemio sub vidpunkto de esperantisto," *Internacia Scienca Revuo* 1, no. 4 (April 1904): 120–122.

67. Quoted in Richard Lorenz, "The 'Délégation pour l'adoption d'une langue auxiliare internationale," in L. Couturat et al., *International Language and Science* (1910): 11–26, on 13.

68. See letter #1 reproduced in Karl Hansel and Fritz Wollenberg, eds., *Aus dem Briefwechsel Wilhelm Ostwalds zur Einführung einer Weltsprache, Mitteilungen der Wilhelm-Ostwald-Gesellschaft zu Großbothen e.V., Sonderheft* 6 (1999), 25.

69. Couturat and Leau, *Histoire de la Langue Universelle*, xii.

70. Clark, *International Language*, 30.

Chapter Five

1. Otto Jespersen, "Finala Diskurso," *Progreso* 7, no. 1 (73) (15 January 1914): 1–6, on 4. This was Jespersen's final lecture of a small series on the problem of a world lan-

guage at the University of Copenhagen in 1913. He delivered it entirely in Ido, without preparing the students beforehand.

2. Wilhelm Ostwald, *Lebenslinien: Eine Selbstbiographie*, 3 vol. (Berlin: Klasing & Co., 1927), III: 146–147. Chapter 5 concerns "Die Weltsprache."

3. Ostwald, *Lebenslinien*, III:141.

4. Albert Léon Guérard, *A Short History of the International Language Movement* (London: T. Fisher Unwin, 1922), 177. For detailed information on Ostwald's involvement with constructed languages, see Günter Anton, "Die Tätigkeit Professor Wilhelm Ostwalds für die internationale Sprache IDO," *Mitteilungen der Wilhelm-Ostwald-Gesellschaft zu Großbothen e.V.* 8, no. 4 (2003): 16–26.

5. Wilhelm Ostwald, "Pri la problemo de la helpa lingvo. II. La mondlingvo," tr. Dr. Helte, *Internacia Scienca Revuo* 1, no. 10 (October 1904): 289–295.

6. Ostwald, *Lebenslinien*, III:151.

7. Reproduced in Hans-Günther Körber, ed., *Aus dem wissenschaftlichen Briefwechsel Wilhelm Ostwalds, II. Teil: Briefwechsel mit Svante Arrhenius und Jacobus Hendricus Van't Hoff* (Berlin: Akademie Verlag, 1969), 196.

8. Letter of 24 March 1907, reproduced in Karl Hansel and Fritz Wollenberg, eds., *Aus dem Briefwechsel Wilhelm Ostwalds zur Einführung einer Weltsprache, Mitteilungen der Wilhelm-Ostwald-Gesellschaft zu Großbothen e.V., Sonderheft* 6 (1999), 42.

9. From the William James Papers, Houghton Library, Harvard University, as quoted in Niles R. Holt, "Wilhelm Ostwald's 'The Bridge,'" *British Journal for the History of Science* 10 (1977): 146–150, on 149n12.

10. Reproduced in Ostwald, *Lebenslinien*, III:143–144.

11. Wilhelm Ostwald, *Sprache und Verkehr* (Leipzig: Akademische Verlagsgesellschaft, 1911), 8.

12. Ostwald paraphrased in Edwin E. Slosson, *Major Prophets of To-Day* (Boston: Little, Brown, and Company, 1916), 222.

13. Wilhelm Ostwald, "Die Weltsprache," reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*: 4–14.

14. For surveys of the events chronicled in this chapter, see for example Guérard, *A Short History of the International Language Movement*, chapter 7; E. Drezen, *Historio de la Mondolinguo: Tra Jarcentoj da Serĉado*, 2d ed., tr. N. Hohlov and N. Nekrasov (Leipzig: Ekrelo, 1931), chapter 2 (from the Esperantist point of view); and Ward Nichols, "The Decision of the Delegation/La Decido Di La Delegitaro," *Internationalist* 2, no. 2 (6) (April-May 1910): 18–19 (from the Idist side). A comprehensive bibliography of Ido publications can be found in Tazio Carlevaro and Reinhard Hauptenthal, *Bibliografio di Ido* (Bellinzona: Hans Dubois, 1999).

15. Guérard, *A Short History of the International Language Movement*, 146–147.

16. Ostwald, *Lebenslinien*, III:165.

17. Peter G. Forster, *The Esperanto Movement* (The Hague: Mouton, 1982), 121–122.

18. Otto Jespersen, *A Linguist's Life*, eds. Arne Juul, Hans F. Nielsen, and Jørgen Erik Nielsen, tr. David Stoner (Odense: Odense University Press, 1995 [1938]), 149. This is the translation of his Danish autobiography: *En Sprogmands Levned* (Copenhagen: Nordisk Forlag, 1938).

19. Jespersen, *A Linguist's Life*, 150.

20. Guérard, *A Short History of the International Language Movement*, 136–140.

21. Otto Jespersen, "The Linguistic Principles Necessary for the Construction of an International Auxiliary Language, with Appendix: Criticism of Esperanto," in L. Couturat, O. Jespersen, R. Lorenz, W. Ostwald, and L. Pfaundler, *International Language and Science: Considerations on the Introduction of an International Language into Science*, tr. F. G. Donnan (London: Constable & Company, 1910): 27–41, on 30.

22. W. J. Clark, *International Language: Past, Present & Future* (London: J. M. Dent, 1907), 99.

23. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 34–35.

24. Ostwald, *Lebenslinien*, III:155.

25. Ostwald to Carlo Bourlet, 16 June 1907, reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 47.

26. Ostwald, *Lebenslinien*, III:167; Jespersen, *A Linguist's Life*, 150.

27. Jespersen, *A Linguist's Life*, 150–151. On "middle course," see Otto Jespersen, *An International Language* (London: George Allen & Uwin, 1928), 42.

28. Quoted in Louis Couturat, "Le choix d'une langue internationale," *Revue du Mois* 7 (January-June 1909): 708–724, on 709.

29. Friedrich Schneeberger, "Pri la nomo di nia linguo," *Progresso* 2, no. 4 (16) (June 1909): 229.

30. Couturat, "Averto," *Progresso* 2, no. 4 (16) (June 1909): 2. Emphasis in original.

31. Max Talmey, "The Auxiliary Language Question," *Modern Language Journal* 23 (1938): 172–186, on 177; Jespersen, *An International Language*, 43.

32. Otto Jespersen, "International Language," *Science* N.S. 30, no. 776 (12 November 1909): 677.

33. That program also had plurals in *i*, invariable adjectives, and no accusative, but in addition eliminated the definite article and had verbal endings of *en*, *in*, and *on*. M. Monnerot-Dumain, *Précis d'interlinguistique générale et spéciale* (Paris: Librairie Maloine, 1960), 103.

34. Couturat, "Le choix d'une langue internationale," 720.

35. Louis Couturat, "Des rapports de la logique et de la linguistique dans le problème de la langue internationale," *Revue de Métaphysique et de Morale* 19 (1911): 509–516, on 512. Emphasis in original. Other Idists believed that credit had been "unjustly ascribed to Ostwald" (Max Talmey, "Word Derivation in a Logical Language," *Modern Language Journal* 24 [1940]: 617–628, on 620), and indeed one can find references to this notion in many nineteenth-century projects.

36. Wilhelm Ostwald, "Chemische Weltliteratur," *Zeitschrift für physikalische Chemie* 76 (January 1911): 1–20, on 5. Emphasis in original.

37. Otto Jespersen, "International Language," *Science* N.S. 31, no. 786 (21 January 1910): 109–112, on 109–110.

38. Esperanto was vulnerable to the same criticism. See Louvan E. Nolting, "The Deficiency of Esperanto as a World Language," *Federal Linguist* 5, no. 1–2 (1973): 18–22.

39. Jespersen, "The Linguistic Principles Necessary for the Construction," 28, 31. Emphasis in original.

40. Louis Couturat, "Pour la langue auxiliaire neutre," *Revue internationale de l'enseignement* 58 (1909): 255–259, on 256; Luther H. Dyer, *The Problem of an International Auxiliary Language and Its Solution in Ido* (London: Putnam, 1923), 115–116; Jespersen, "The Linguistic Principles Necessary for the Construction," 32.

41. Couturat, "D'une application de la logique au problème de la langue internationale," *Revue de Métaphysique et de Morale* 16 (1908): 761–769, on 768.

42. Couturat, "D'une application de la logique au problème de la langue internationale," 764. Emphasis in original.

43. Clark, *International Language*, 3n.

44. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 55.

45. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 57. Emphasis in original.

46. Guérard, *A Short History of the International Language Movement*, 149.

47. Louis Couturat and Léopold Leau, *Histoire de la Langue Universelle* (Paris: Librairie Hachette, 1903), 152.

48. Ostwald, *Sprache und Verkehr*, 23. See also Jespersen, *An International Language*, 36; Richard Lorenz, "The 'Delégation pour l'adoption d'une langue auxiliare internationale,'" in L. Couturat et al., *International Language and Science* (1910): 11–26, on 16; and P. Ahlberg, "A Few Statistics," *Internationalist* 2, no. 4 (8) (July 1910): 63–65, on 65.

49. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 55–56.

50. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 65. Emphasis in original.

51. Quoted in "Pri la alvoko 'Al la Delegitaro, al la Esperantistaro,'" *Internacia Scienca Revuo* 5, no. 49 (January 1908): 15–18, on 17. Emphasis in original. This letter was written in German and translated by the editors into Esperanto.

52. Ernest Naville et al., "Al la Delegitaro, al la Esperantistaro," *Internacia Scienca Revuo* 4, no. 48 (December 1907): 389–393, on 392.

53. Naville et al., "Al la Esperantistaro," *Internacia Scienca Revuo* 5, no. 49 (January 1908): 3–6, on 5.

54. See the very detailed letter by Baudoin de Courtenay, who had been a member of the Delegation committee, reproduced in Edmond Privat, *Historio de la Lingvo Esperanto*, vol. 2: *La Movado, 1900–1927* (Leipzig: Ferdinand Hirt & Sohn, 1927), 62–66.

55. Quoted in René Centassi and Henri Masson, *L'homme qui a défié Babel: Ludwik Lejzer Zamenhof* (Paris: Éditions Ramsay, 1995), 249.

56. Walter B. Sterrett, "To Esperantists and Idists; Importance of Mutual Good Will," *Internationalist* 1, no. 2 (July 1909): 5–6, on 5; Walther Borgius, *Warum ich Esperanto verließ: Eine Studie über die gegenwärtige Krisis und die Zukunft der Weltsprachen-Bewegung* (Berlin: Liebheit & Thiesen, 1908).

57. David K. Jordan, "Esperanto and Esperantism: Symbols and Motivations in a Movement for Linguistic Equality," in Humphrey Tonkin, ed., *Esperanto, Interlinguistics, and Planned Language* (Lanham, MD: University Press of America, 1997), 39–65, on 43; Forster, *The Esperanto Movement*, 135–136.

58. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 66.

59. Reproduced in Marjorie Boulton, *Zamenhof: Creator of Esperanto* (London: Routledge and Kegan Paul, 1960), 126.

60. Jespersen, *A Linguist's Life*, 153.

61. Louis de Beaufront, "Déclaration de Ido/Deklaro de Ido," *L'Esperantiste* 11 (May 1908): 97–100, on 97 and 99.

62. See, for example, Edmond Privat, *The Life of Zamenhof*, tr. Ralph Eliott (Oakville, ON: Esperanto Press, 1963 [1920]), 82–83.

63. Jespersen, *A Linguist's Life*, 149. The same phrasing is used in Jespersen, *An International Language*, 42.

64. Drezen, *Historio de la Mondolinguo*, 185; Privat, *Historio de la Lingvo Esperanto*, II: 58.

65. Boulton, *Zamenhof*, 131.

66. Forster, *The Esperanto Movement*, 130 (quotation); Monnerot-Dumaine, *Précis d'interlinguistique générale et spéciale*, 41.

67. Ostwald, *Sprache und Verkehr*, 29. On the symbolism provided by de Beaufront's authorship, see Privat, *Historio de la Lingvo Esperanto*, II: 57.

68. G. Aymonier and L. Couturat, "Ido et Esperanto," *Revue du Mois* 9 (January-June 1910): 219–229; Louis Couturat, "Entre l'Ido et l'Esperanto," *Revue mondiale* (April 1912): 381–392; idem, "Ido ou français," *La grande revue* (25 February 1910): 791–793; idem, "Entre Idistes et Espérantistes," *La Revue* 78 (1909): 110–113.

69. Louis Couturat, "'Wait until Zamenhof is Dead'/'Expektez la Morto di Zamenhof!,'" *Internationalist* 2, no. 5–6 (August-September 1910): 77–81, on 80. Emphasis in original. See also idem, "Makiavelatra Taktiko," *Progreso* 2, no. 8 (20) (October 1909): 449–452, on 450.

70. Couturat, "L'Ido devant la science: Lettre ouverte à M. A. Cotton, Professeur à la Sorbonne," *La Langue Auxiliaire* 3 (1910): 21–27, on 22.

71. Couturat, "Ido contre Esperanto," *La coopération des idées* (1912): 444–449, on 446.

72. Letter of 4 November 1907, reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 57.

73. Jordan, "Esperanto and Esperantism," 43.

74. Drezen, *Historio de la Mondolinguo*, 186.

75. Couturat, "Pri Nia Metodo," *Progreso* 2, no. 10 (22) (December 1909): 579–582, on 580–581.

76. Couturat, "Le choix d'une langue internationale," 722.

77. Lorenz, "The 'Délégation pour l'adoption d'une langue auxiliare internationale,'" 20.

78. Jespersen, "The Linguistic Principles Necessary for the Construction," 37. In 1924, in a general linguistic text, he would repeatedly invoke Ido as an example of the rational development of language: Otto Jespersen, *The Philosophy of Grammar* (Chicago: University of Chicago Press, 1992 [1924]), 41, 60, 136, 208n1, 232, 321n1. For Couturat, see for example his "On the Application of Logic to the Problem of an International Language," in L. Couturat et al., *International Language and Science* (1910): 41–52.

79. Couturat, "Le choix d'une langue internationale," 723.

80. Leopold Pfaundler, "The Need for a Common Scientific Language," in L. Couturat et al., *International Language and Science* (1910): 1–10, on 6.

81. Couturat, "Entre Idistes et Espérantistes," 112.

82. Jespersen, "International Language [1910]," 112.

83. Nichols, "Hear the Other Side," *Internationalist*, no. 3–4 (February 1910): 8–9,

on 9. For Couturat's interest in Lamarck, see his "La Stabileso di la Vivo," *Progreso* 5, no 3 (51) (May 1912): 140–141. This issue of *Progreso* contains several articles on Gregor Mendel, on Lamarck, and on heredity in general—all translated into Ido by Couturat.

84. Couturat, "Autour d'une Langue internationale," *La Revue* 87 (1910): 381–385, on 383–384. Emphasis in original.

85. See E. H. MacPike, "La Praktikal Utileso di Ido/The Practical Usefulness of Ido," *Internationalist*, no. 3–4 (February 1910): 11–12; C. S. Pearson, "Kiropraktiko," *Internationalist* 2, no. 2 (6) (April-May 1910): 28; and Louis Couturat, *Internaciona matematikal lexiko en Ido, Germana, Angla, Franca, e Italiana* (Jena: Gustav Fischer, 1910).

86. Reproduced in Körber, ed., *Aus dem wissenschaftlichen Briefwechsel Wilhelm Ostwalds*, 320.

87. Reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 113.

88. Quoted in "Prof. William Ostwald and International Language," *Internationalist*, no. 3–4 (February 1910): 12–13, on 13. On the donation, see also Grete Ostwald, *Wilhelm Ostwald: Mein Vater* (Stuttgart: Berliner Union, 1953), 110; Slosson, *Major Prophets of To-Day*, 222n1; and Eugen Wüster, *Internationale Sprachnormung in der Technik, besonders in der Elektrotechnik (Die nationale Sprachnormung und ihre Verallgemeinerung)*, 2d ed. (Bonn: H. Bouvier u. Co. Verlag, 1966), 335.

89. Slosson, *Major Prophets of To-Day*, 223.

90. Wilhelm Ostwald, "The Question of Nomenclature," in L. Couturat et al., *International Language and Science* (1910): 61–68, on 61, 67.

91. Letter of 4 January 1911, reproduced in Körber, ed., *Aus dem wissenschaftlichen Briefwechsel Wilhelm Ostwalds*, 322.

92. Reproduced in Körber, ed., *Aus dem wissenschaftlichen Briefwechsel Wilhelm Ostwalds*, 323.

93. See the letters to Ostwald of 24 and 31 December 1910, reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 124.

94. Reproduced in Körber, ed., *Aus dem wissenschaftlichen Briefwechsel Wilhelm Ostwalds*, 323–325, quotation on 325.

95. See the letter of 25 January 1901, reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 129.

96. Ostwald, *Lebenslinien*, III:176.

97. Ostwald, "Chemische Weltliteratur," 111.

98. Ostwald, "Chemische Weltliteratur," 2–3.

99. Ostwald, "Chemische Weltliteratur," 7.

100. Ostwald, "Memorial on the Foundation of an International Chemical Institute," *Science* N.S. 40, no. 1022 (31 July 1914): 147–158, on 155.

101. Alexander Batek, "Pri la ĥemia nomigado," *Internacia Scienca Revuo* 6, nos. 68–69 (August-September 1909): 264–266, on 265. For Couturat's accusations of plagiarism, see *Progreso* 5, no. 3 (51) (May 1912): 162.

102. Maurice Rollet de l'Isle, "Konsilaro por la farado de la sciencaj kaj teknikaj vortoj," *Internacia Sciencia Revuo* 7, no. 83 (November 1910): 279–295; no. 84 (December 1910): 311–334; 8, no. 85 (January 1911): 1–21; no. 86 (February 1911): 33–49.

103. Ostwald, "Memorial on the Foundation of an International Chemical Institute," 147, 155. On the Bridge, see Holt, "Wilhelm Ostwald's 'The Bridge,'" although at points this piece is unreliable. For example, on p. 146 Holt claims that the universal language promoted by Ostwald was Esperanto.

104. Otto Jespersen, "Grava Propozo," *Internationalist* 2, no. 3 (7) (June 1910): 45–46, on 45 (Jespersen) and 46 (Couturat). Couturat had earlier been a fierce defender of eternal experimentation: Couturat, "Entre l'Ido et l'Esperanto," 390–391.

105. F. Schneeberger and L. Couturat, "Pri la periodo di stabileso," *Progreso* 5, no. 3 (51) (May 1912): 191. On Solothurn, see *Progreso* 7, no. 4 (76) (April 1914): 197. In his history of constructed languages, Esperantist Ernest Drezen was convinced that the period of stability had damaged Ido by restricting innovation and dampening advocates' enthusiasm: Drezen, *Historio de la Mondolinguo*, 187.

106. Guérard, *A Short History of the International Language Movement*, 122–123.

107. Wüster, *Internationale Sprachnormung in der Technik*, 335; Drezen, *Historio de la Mondolinguo*, 198–199.

Chapter Six

1. Franz Thierfelder, *Die deutsche Sprache im Ausland*, 2 v. (Hamburg: R. v. Decker, 1956–1957), I:18.

2. Quoted in Günter Anton, "Die Tätigkeit Professor Wilhelm Ostwalds für die internationale Sprache IDO," *Mitteilungen der Wilhelm-Ostwald-Gesellschaft zu Großbothen e.V.* 8, no. 4 (2003): 16–26, on 22. Ellipses in original.

3. Wilhelm Ostwald, "Weltdeutsch," *Monistische Sonntagspredigten*, no. 36 (31 October 1915): 545–559, on 553.

4. Ostwald, "Weltdeutsch," 555–556.

5. Ostwald, "Weltdeutsch," 557. J. A. Large attributes the program of Weltdeutsch to a Professor Baumann in Munich, also in 1915. Large, *The Foreign-Language Barrier: Problems in Scientific Communication* (London: André Deutsch, 1983), 148. I have not been able to demonstrate a connection between Baumann and Ostwald.

6. Leopold Pfaundler to Wilhelm Ostwald, 30 December 1915, reproduced in Karl Hansel and Fritz Wollenberg, eds., *Aus dem Briefwechsel Wilhelm Ostwalds zur Einführung einer Weltsprache, Mitteilungen der Wilhelm-Ostwald-Gesellschaft zu Großbothen e.V., Sonderheft* 6 (1999), 147.

7. Ostwald to Pfaundler, 12 January 1916, reproduced in Hansel and Wollenberg, *Aus dem Briefwechsel Wilhelm Ostwalds*, 148.

8. Otto Jespersen to Franz Boas, 4 December 1914, Franz Boas Papers, Mss.B.B61, APSL, Folder: "Jespersen, Otto."

9. A. Meillet, *Les langues dans l'Europe nouvelle* (Paris: Payot & Cie, 1918), 292.

10. Félix Henneguy, "Du rôle de l'Allemagne dans l'évolution des sciences biologiques," *Revue scientifique* 53 (27 February-6 March 1915): 70–74, on 71.

11. W. F. Twaddell, "Standard German," *Anthropological Linguistics* 1, no. 3 (1959): 1–7, on 1; Ulrich Ammon, *Die internationale Stellung der deutschen Sprache* (Berlin: Walter de Gruyter, 1991), 27.

12. W. B. Lockwood, *An Informal History of the German Language* (Cambridge: W. Heffer and Sons, 1965), 116.

13. Ruth H. Sanders, *German: Biography of a Language* (New York: Oxford University Press, 2010), 98; R. E. Keller, *The German Language* ([Atlantic Highlands], NJ: Humanities Press, 1978), 237.

14. Twaddell, "Standard German," 1, 3; Lockwood, *An Informal History of the German Language*, 109; Keller, *The German Language*, 338–339.

15. Jeanne Pfeiffer, "La création d'une langue mathématique allemande par Albrecht Dürer. Les raisons de sa non réception," in Roger Chartier and Pietro Corsi, eds., *Sciences et langues en Europe* (Paris: European Communities, 2000 [1994]): 77–90.

16. Quoted in Adolf Bach, *Geschichte der deutschen Sprache*, 8th ed. (Heidelberg: Quelle & Meyer, 1965 [1938]), 331.

17. Ulrich Ricken, "Zum Thema Christian Wolff und die Wissenschaftssprache der deutschen Aufklärung," in Heinz L. Kretzenbacher and Harald Weinrich, eds., *Linguistik der Wissenschaftssprache* (Berlin: Walter de Gruyter, 1995): 41–90; Eric A. Blackall, *The Emergence of German as a Literary Language, 1700–1775*, 2d ed. (Ithaca: Cornell University Press, 1978 [1959]).

18. Lockwood, *An Informal History of the German Language*, 129–130.

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Chapter Seven

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62. See, for example, Meitner to von Laue, 19 November 1940, in Jost Lemmerich, ed., *Lise Meitner—Max von Laue: Briefwechsel 1938–1948* (Berlin: ERS Verlag, 1998), 104.

63. Meitner to von Laue, 23 December 1940, in Lemmerich, *Lise Meitner—Max von Laue*, 108.

64. Max von Laue, "Mein physikalischer Werdegang," from Hans Hartmann, ed., *Schöpfer des neuen Weltbildes* (Hamburg: Deutsche Hausbücherei, 1952), 178–207, reproduced in von Laue, *Gesammelte Schriften und Vorträge*, 3 v. (Braunschweig: Freidrich Vieweg & Sohn, 1961), III: xi.

65. Von Laue, "Mein physikalischer Werdegang," xi–xii.

66. Meitner to Eva von Bahr-Bergius, 21 June 1944, reproduced in Lemmerich, *Lise Meitner zum 125. Geburtstag*, 112.

67. Sime, *Lise Meitner*, 358.

68. Meitner to von Laue, 28 June 1946, in Lemmerich, *Lise Meitner—Max von Laue*, 452–453.

69. See Meitner to Hahn, 27 June 1945, reproduced in Lemmerich, *Lise Meitner zum 125. Geburtstag*, 116–117.

70. Meitner to von Laue, 12 November 1946, in Lemmerich, *Lise Meitner—Max von Laue*, 470–471.

71. P. W. Bridgman, "'Manifesto' by a Physicist," *Science* 89, no. 2304 (24 February 1939): 179.

72. Warren Weaver, diary entry of 25 May 1947, Rockefeller Archive Center, RG 12.1, p. 45, reproduced in Klaus Hentschel, *The Mental Aftermath: The Mentality of German Physicists, 1945–1949*, tr. Ann M. Hentschel (New York: Oxford University Press, 2007), 24.

73. "The Fate of German Science: Impressions of a BIOS Officer," *Discovery* (August 1947): 239–243.

74. Gerhard Rammer, "'Cleanliness among Our Circle of Colleagues': The German Physical Society's Policy toward Its Past," in Hoffmann and Walker, eds., *The German Physical Society in the Third Reich* (2012): 367–421, on 377.

75. Niko Tinbergen to Margaret Nice, 23 June 1945, reproduced in Deichmann, *Biologists under Hitler*, 203.

76. Samuel A. Goudsmit, "Our Task in Germany," *Bulletin of the Atomic Scientists* 4, no. 4 (1948): 106.

77. For Meitner, see Meitner to von Laue, 12 November 1946, in Lemmerich, *Lise Meitner—Max von Laue*, 470; and Meitner to Hahn, 27 June 1945, reproduced in Lemmerich, *Lise Meitner zum 125. Geburtstag*, 117. On other émigrés, see Wolff, "Marginalization and Expulsion of Physicists under National Socialism," 61.

78. Henry J. Kellermann, *Cultural Relations as an Instrument of U.S. Foreign Policy: The Educational Exchange Program between the United States and Germany, 1945–1954* (Washington, DC: Department of State, 1978), 3.

79. Arendt in Arendt and Gaus, "Was bleibt?," 23.

Chapter Eight

1. D. Zaslavskii, "Velikii iazyk nashei epokhi," *Literaturnaia gazeta* (1 January 1949).

2. The full machine consisted of the 701 Analytic Control Unit, the 706 Electrostatic Storage Unit, the 711 Punched Card Reader, the 716 Alphabetical Printer, the 721 Punched Card Recorder, the 726 Magnetic Tape Readers and Recorders, the 731 Magnetic Drum Reader and Recorder, and a Power Supply and Distribution Box. On computer hardware in this period, see Mina Rees, "Computers: 1954," *Scientific Monthly* 79, no. 2 (August 1954): 118–124; and Cuthbert C. Hurd, "Computer Development at IBM," in N. Metropolis, J. Howlett, and Gian-Carlo Rota, eds., *A History of Computing in the Twentieth Century: A Collection of Essays* (New York: Academic Press, 1980): 389–418. For all Hurd's pride in the experiment, he got the name of his Georgetown collaborator wrong, naming him "Professor Dorot" (on 406).

3. J. B. Donnelly, IBM Press Release, 8 January 1954, GUA-SLL 1:1–6/1954.

4. Dostert quoted in W. Schweisheimer, "Language Translation by Electronic Computer," *Mechanical World* (December 1955): 534–535, on 534.

5. Quoted in Dorothy M. Bishop, "Breaking the Language Barrier," *Phi Delta Kappan* 35, no. 8 (May 1954): 315–317, 320, on 317.

6. Dostert quoted in Donnelly Press Release, 8 January 1954, GUA-SLL 1:1–6/1954.

7. See, for example: Jacob Ornstein, "Mechanical Translation: New Challenge to Communication," *Science* 122, no. 3173 (21 October 1955): 745–748; "Language Translation by the Electronic 'Brain,'" *Science News-Letter* 65, no. 4 (23 January 1954): 59; and William N. Locke, "Speech Typewriters and Translating Machines," *PMLA* 70, no. 2 (April 1955): 23–32, on 30. As W. John Hutchins has noted in his excellent history of the experiment, science was deemphasized in most mainstream media accounts as "the newspaper reporters tended to choose only non-chemistry examples, since these gave impressions of the quality of the translations which could be more readily appreciated by readers than the chemistry ones." Hutchins, "The First Public Demonstration of Machine Translation: The Georgetown-IBM System, 7th January 1954," (March 2006), available at http://hutchinsweb.me.uk/GU-IBM-2005.pdf, accessed 16 September 2011, on p. 12. Hutchins includes a sizeable bibliography of the press accounts.

8. Leon Dostert, "Report on Academic Developments, The Institute of Languages and Linguistics, 1952–53, Projected Activities, 1953–54," 7 October 1953, GUA-SLL 1:1953.

9. Leon E. Dostert to Edward B. Bunn, S.J., 24 November 1953, GUA-SLL 1:1953.

10. Memorandum of phone call, Robert Avery to Leon Dostert, 11 December 1953, 2 pm, GUA-SLL 1:1953.

11. N. W. Baklanoff, "Scientific Russian," *Modern Language Journal* 32 (1948): 190–194, on 191.

12. J. G. Tolpin, "Teaching of Scientific Russian," *American Slavic and East European Review* 4 (August 1945): 158–164, on 158; idem, "The Place of Russian Scientific Literature in Bibliographical Work," *Journal of Chemical Education* 21 (July 1944): 336–342, on 336; Kurt Gingold, "Translation Pools—Ideal and Reality," *Journal of Chemical Documentation* 1, no. 2 (1961): 14–19, on 14; and Joseph J. Gwirtsman, "Coverage of Russian Chemical Literature in Chemical Abstracts," *Journal of Chemical Documentation* 1, no. 2 (1961): 38–44, on 38.

13. Boris I. Gorokhoff, *Providing U.S. Scientists with Soviet Scientific Information*, rev. ed. (Washington, DC: Publications Office of the National Science Foundation, 1962), i.

14. E. J. Crane, "Growth of Chemical Literature: Contributions of Certain Nations and the Effects of War," *Chemical & Engineering News* 22, no. 17 (10 September 1944): 1478–1481, 1496, on 1478, 1481 (quotation). The number of Russian chemists grew by twenty-five times between 1875 and 1940, and they were increasingly productive, producing eighty times the quantity of publications over this period. I. I. Zaslavskii, "Rol' russkikh uchenykh v sozdanii mirovoi khimii," *Uspekhi khimii* 13, no. 4 (1944): 328–335, on 331.

15. Gingold, "Translation Pools," 14.

16. Advisory Panel on Scientific Information, "Minutes of the First Meeting," 12 October 1953, NSF Records, RG 307, Box 18, Folder: "Scientific Information Office: Advisory Panel on Scientific Information," p. 4.

17. Saul Herner, "American Use of Soviet Medical Research," *Science*, N.S. 128, no. 3314 (4 July 1958): 9–15, on 14.

18. J. G. Tolpin, "Surveying Russian Technical Publications: A Brief Course," *Science* 146, no. 3648 (27 November 1964): 1143–1144, on 1143.

19. Office of Scientific Information, "International Exchange of Scientific Information," 2 November 1955, NSF Records, RG 307, Box 18, Folder: "Scientific Information," page 19. The Russian language barrier had been cited in Vannevar Bush's original position paper calling for the creation of this organization: Bush, *Science: The Endless Frontier* (Washington, DC: Government Printing Office, 1945), 114.

20. George Alan Connor, Doris Tappan Connor, William Solzbacher, and J. B. Se-Tsien Kao, *Esperanto: The World Interlanguage*, 2d rev. ed. (South Brunswick: Thomas Yoseloff, 1966 [1948]), 4, 32.

21. For a complete list of members of the IALA, see "Practical World Language," *Science News-Letter* 66, no. 3 (17 July 1954): 34; and Watson Davis, "Practical World Language," *Science News-Letter* 62 (5 July 1952): 10–11.

22. Gode in IALA, *Interlingua-English: A Dictionary of the International Language* (New York: Storm, 1951), xxi.

23. Alexander Gode and Hugh E. Blair, *Interlingua: A Grammar of the International Language* (New York: Storm Publishers, 1951), v.

24. Alexander Gode, *Interlingua: A Prime Vista* (New York: Storm Publishers, 1954).

25. Andrew Large, *The Artificial Language Movement* (Oxford: Basil Blackwell, 1985), 151.

26. Arika Okrent, *In the Land of Invented Languages: Esperanto Rock Stars, Klingon Poets, Loglan Lovers, and the Mad Dreamers Who Tried to Build a Perfect Language* (New York: Spiegel & Grau, 2009), 210.

27. E. Glyn Lewis, *Multilingualism in the Soviet Union: Aspects of Language Policy and Its Implementation* (The Hague: Mouton, 1972), 50. On propaganda, see Selig S. Harrison, *The Most Dangerous Decades: An Introduction to the Comparative Study of Language Policy in Multi-Lingual States* (New York: Language and Communication Research Center, Columbia University, 1957), 24–27.

28. The exceptions were Georgian, Armenian, and Abkhaz in the Caucasus, which used their traditional scripts; Estonian, Lithuanian, Latvian, and Karelian in the Baltic region, which kept Latin scripts; and Yiddish, which retained Hebrew letters. (Yiddish was strongly repressed in the postwar period.) For the information on Soviet language policy in this section, see Barbara A. Anderson and Brian D. Silver, "Equality, Efficiency, and Politics in Soviet Bilingual Education Policy, 1934–1980," *American Political Science Review* 78, no. 4 (December 1984): 1019–1039; Uriel Weinreich, "The Russification of Soviet Minority Languages," *Problems of Communism* 2, no. 6 (1953): 46–57; and Michael Kirkwood, ed., *Language Planning in the Soviet Union* (Basingstoke: Macmillan, 1989).

29. Nicholas DeWitt, *Soviet Professional Manpower: Its Education, Training, and Supply* (Washington, DC: NSF, 1955), 55. The situation became even more sharply Russophone, especially in technical publication, by the 1970s. Iu. D. Desheriev, *Razvitie obshchestvennykh funktsii literaturnykh iazykov* (Moscow: Nauka, 1976), 11–12, 17.

30. Tatjana Kryuchkova, "English as a Language of Science in Russia," in Ulrich Ammon, ed., *The Dominance of English as a Language of Science: Effects on Other Languages and Language Communities* (Berlin: Mouton de Gruyter, 2001): 405–423, on 407.

31. T. P. Lomtev, "I. V. Stalin o razvitii natsional'nykh iazykov v epokhu sotsializma," *Voprosy filosofii* 1(6) (1949): 131–141, on 136.

32. J. G. Garrard, "The Teaching of Foreign Languages in the Soviet Union," *Modern Language Journal* 46 (1962): 71–74; Jacob Ornstein, "Foreign Language Training in the Soviet Union—A Qualitative View," *Modern Language Journal* 42 (1958): 382–392, on 388.

33. Alexander G. Korol, *Soviet Education for Science and Technology* (New York: Technology Press and John Wiley & Sons, 1957), 230. Emphasis in original. See also pages 121, 185–186, and 228.

34. For the contrasting positions, see P. V. Terent'ev, "Obiazatel'noe uslovie uspeshnoi podgotovki kadrov," *Vestnik vysshei shkoly*, no. 12 (December 1955): 50–51; and A. F. Plate, "Kakoi inostrannyi iazyk v pervuiu ochered' neobkhodim sovetskomu khimiku," *Uspekhi khimii* 9, no. 5 (1940): 589–595, on 593.

35. Dale Lockard Barker, "Characteristics of the Scientific Literature Cited by

Chemists of the Soviet Union" (PhD dissertation, University of Illinois-Urbana, 1966). For the 80% figure, see Department of Scientific and Industrial Research, *Scientific and Technical Information in the Soviet Union: Report of the D.S.I.R.–Aslib Delegation to Moscow and Leningrad, 7th–24th June, 1963* (London: Department of Scientific and Industrial Research, 1964), 17.

36. J. G. Tolpin, J. Danaczko Jr., R. A. Liewald, et al., "The Scientific Literature Cited by Russian Organic Chemists," *Journal of Chemical Education* 28 (May 1951): 254–258, on 254.

37. Ornstein, "Foreign Language Training in the Soviet Union," 392.

38. See Nils Roll-Hansen, *The Lysenko Effect: The Politics of Science* (Amherst, NY: Humanity Books, 2005) and David Joravsky, *The Lysenko Affair* (Cambridge, MA: Harvard University Press, 1970).

39. The theory is complicated and not entirely internally consistent. For English-language accounts, see Ethan Pollock, *Stalin and the Soviet Science Wars* (Princeton: Princeton University Press, 2006), chapter 5; Jeffrey Ellis and Robert W. Davies, "The Crisis in Soviet Linguistics," *Soviet Studies* 2, no. 3 (January 1951): 209–264; W. K. Matthews, "The Japhetic Theory," *Slavonic and East European Review* 27, no. 68 (December 1948): 172–192; M. Miller, "Marr, Stalin, and the Theory of Language," *Soviet Studies* 2, no. 4 (April 1951): 364–371.

40. Jindrich Kucera, "Soviet Nationality Policy: The Linguistic Controversy," *Problems of Communism* 3, no. 2 (March-April 1954): 24–29, on 26.

41. Quoted in E. Drezen, *Osnovy iazykoznaniia: Teorii i istorii mezhdunarodnogo iazyka* (Moscow: Izd. TsK SESR, 1932), 26.

42. J. G. Tolpin, "Searching the Russian Technical Literature," *Journal of Chemical Education* 23 (October 1946): 485–489, on 488.

43. Quoted in Nikolai Krementsov, *The Cure: A Story of Cancer and Politics from the Annals of the Cold War* (Chicago: University of Chicago Press, 2002), 131.

44. John Turkevich, "Science," in Harold H. Fisher, ed., *American Research on Russia* (Bloomington: Indiana University Press, 1959): 103–112, on 105–106.

45. Theodosius Dobzhansky, "Russian Genetics," in Ruth C. Christman, ed., *Soviet Science* (Washington, DC: AAAS, 1952): 1–7, on 6; J. R. Kline, "Soviet Mathematics," in ibid.: 80–84, on 82–83.

46. Albert Parry, *America Learns Russian: A History of the Teaching of the Russian Language in the United States* (Syracuse: Syracuse University Press, 1967), 50–58; Rudolf Sturm, "The Changing Aspects of Teaching Russian," in Joseph S. Roucek, ed., *The Study of Foreign Languages* (New York: Philosophical Library, 1968): 170–183, on 175.

47. Sturm, "The Changing Aspects of Teaching Russian," 173.

48. Jacob Ornstein, "Structurally Oriented Texts and Teaching Methods since World War II: A Survey and Appraisal," *Modern Language Journal* 40, no. 5 (May 1956): 213–222; idem, *Slavic and East European Studies: Their Development and Status in the Western Hemisphere* (Washington, DC: Department of State, Office of Intelligence Research, 1957), 9; Arthur Prudden Coleman, "The Teaching of Russian in the United States," *Russian Review* 4, no. 1 (Autumn 1944): 83–88; Parry, *America Learns Russian*, 107.

49. Parry, *America Learns Russian*, 112, 130; Jacob Ornstein, "A Decade of Russian Teaching: Notes on Methodology and Textbooks," *Modern Language Journal* 35 (1951): 263–279, on 263; Sturm, "The Changing Aspects of Teaching Russian," 177.

50. Parry, *America Learns Russian*, 152; Fan Parker, "Report of the National Information Center on the Status of Russian in Secondary Schools," *Slavic and East European Journal* 3, no. 1 (Spring 1959): 55–61.

51. L. E. Dostert, Frederick D. Eddy, W. P. Lehmann, and Albert H. Markwardt, "Tradition and Innovation in Language Teaching," *Modern Language Journal* 44, no. 5 (May 1960): 220–226, on 220.

52. William B. Edgerton, "A Modest Proposal: The Teaching of Russian in America," *Slavic and East European Journal* 6, no. 4 (Winter 1962): 354–372, on 357. On rising enrollments, see Sturm, "The Changing Aspects of Teaching Russian," 179.

53. Alan T. Waterman, "Research and the Scholar," remarks at the dedication of the Price Gilbert Library at the Georgia Institute of Technology, 20 November 1953, Waterman Papers, LOC, Box 57, Folder: "1953 Apr.8-Dec.29," p. 14.

54. Jacob Chaitkin, "The Challenge of Scientific Russian," *Scientific Monthly* 60, no. 4 (April 1945): 301–306, on 301.

55. George A. Znamensky, *Elementary Scientific Russian Reader* (New York: Pitman, 1944), v.

56. V. A. Pertzoff, *Translation of Scientific Russian* (New York: Exposition-University Books, [1964]), 41.

57. Tolpin, "Teaching of Scientific Russian," 160. There were, of course, others who claimed that the presence of false cognates and convoluted sentence structure made translating scientific Russian in many ways *harder* than "standard" Russian. See, for example, Vijay Pandit, "'Misleading' Words in Scientific Translation from Russian into English," *Babel* 25 (1979): 148–151; and John Turkevich, "Scientific Russian," *American Scientist* 34, no. 3 (July 1946): 464–466, 470, on 464.

58. Lorraine T. Kapitanoff, "The Teaching of Technical Russian," *Slavic and East European Journal* 7, no. 1 (Spring 1963): 51–56, on 52.

59. David Kaiser, "The Physics of Spin: Sputnik Politics and American Physicists in the 1950s," *Social Research* 73, no. 4 (Winter 2006): 1225–1252, on 1239–1240; Parry, *America Learns Russian*, 146; Arthur Prudden Coleman, *A Report on the Status of* Russian and Other Slavic and East European Languages *in the Educational Institutions of the United States, Its Territories, Possessions and Mandates, with Additional Data on Similar Studies in Canada and Latin America* (New York: American Association of Teachers of Slavic and East European Languages, 1948).

60. J. G. Tolpin, "The Present Status of Teaching Russian for Scientists," *Modern Language Journal* 33, no. 1 (January 1949): 27–30, on 27. For self-training, see James W. Perry, "Chemical Russian, Self-Taught," *Journal of Chemical Education* (August 1944): 393–398.

61. Kapitanoff, "The Teaching of Technical Russian," 51.

62. E. F. Langley, "New Course in Russian," 8 September 1942, MIT Archives, AC359, Box 1, Folder 1.

63. Baklanoff, "Scientific Russian"; R. D. Burke, "Some Unique Problems in the Development of Qualified Translators of Scientific Russian," RAND Report P-1698 (12 May 1959); Tolpin, "Surveying Russian Technical Publications," 1143; and George E. Condoyannis, "Russian for Scientists," *Modern Language Journal* 32, no. 5 (May 1948): 392–393.

64. Ornstein, *Slavic and East European Studies*, 21–22.

65. Burke, "Some Unique Problems in the Development of Qualified Translators,"

7. See also C. R. Buxton and H. Sheldon Jackson, *Russian for Scientists: A Grammar and Reader* (New York: Interscience, 1960), 4, 73.

66. James W. Perry, "Translation of Russian Technical Literature by Machine: Notes on Preliminary Experiments," *Mechanical Translation* 2, no. 1 (July 1955): 15–26, on 15.

67. For example, James W. Perry, *Scientific Russian: A Textbook for Classes and Self-Study* (New York: Interscience Publishers, 1950); idem, *Chemical Russian, Self-Taught* (Easton, PA: Journal of Chemical Education, 1948); Noah D. Gershevsky, ed., *Scientific Russian Reader: Selected Modern Readings in Chemistry and Physics* (New York: Pitman Publishing, 1948); George E. Condoyannis, *Scientific Russian: A Concise Description of the Structural Elements of Scientific and Technical Russian* (New York: John Wiley & Sons, 1959); John Turkevich and Ludmilla B. Turkevich, *Russian for the Scientist* (Princeton: D. Van Nostrand, 1959); Buxton and Jackson, *Russian for Scientists*; and Pertzoff, *Translation of Scientific Russian*.

68. Parry, *America Learns Russian*, 149. On teaching by radio in the United States and Great Britain, respectively, see Coleman, "The Teaching of Russian in the United States," 87–88; and Ariadne Nicolaeff, "Problems of Teaching Russian by Radio," in C. V. James, ed., *On Teaching Russian* (Oxford: Pergamon, 1963), 64–75.

69. Biographical information is drawn from: R. Ross Macdonald, "Léon Dostert," in William M. Austin, ed., *Papers in Linguistics in Honor of Léon Dostert* (The Hague: Mouton, 1967): 9–14; "New Institute of Linguistics," *Georgetown University Alumni Bulletin* (Fall 1949): 5, 16; *The Lado Years, 1960–1973* (Washington, DC: Georgetown University Press, 1973), 1–2; and Muriel Vasconcellos, "The Georgetown Project and Léon Dostert: Recollections of a Young Assistant," in W. John Hutchins, ed., *Early Years in Machine Translation: Memoirs and Biographies of Pioneers* (Amsterdam: John Benjamins, 2000): 87–96.

70. This does not mean that everyone liked him. Michael Zarechnak, one of his employees at Georgetown on developing MT, once wrote tactfully that "Dostert was a person toward whom an observer could not display a neutral attitude." Michael Zarechnak, "The History of Machine Translation," in Bożena Henisz-Dostert, R. Ross Macdonald, and Michael Zarechnak, *Machine Translation* (The Hague: Mouton, 1979): 1–87, on 21. Some of the translators in Nuremberg dubbed him "le Petit Napoléon." Francesca Gaiba, *The Origins of Simultaneous Interpretation: The Nuremberg Trial* (Ottowa: Ottowa University Press, 1998), 134.

71. Léon Dostert, *France and the War*, No. 24 *America in a World at War* (New York: Oxford University Press, 1942).

72. See Gaiba, *The Origins of Simultaneous Interpretation*. On the relationship with Watson, see Vasconcellos, "The Georgetown Project and Léon Dostert," 87n.

73. L. E. Dostert, "The Georgetown Institute Language Program," *PMLA* 68, no. 2 (April 1953): 3–12. See also William M. Austin's dedicatory foreword in *Papers in Linguistics in Honor of Léon Dostert*, 5.

74. L. E. Dostert, "Languages in Preparedness: Link or Obstacle?," *Armor* (May-June 1951): 12–14, on 12–13.

75. The memorandum is reprinted as Warren Weaver, "Translation," in William N. Locke and A. Donald Booth, eds., *Machine Translation of Languages: Fourteen Essays* (Cambridge, MA: MIT Press, 1955), 15–23, quotation on 18. On Booth's early impact and claims to priority, see Andrew D. Booth, "Mechanical Translation," *Computers and Automation* 2, no. 4 (May 1953): 6–8; and idem, ed., *Machine Translation* (Amsterdam: North-Holland, 1967), vi. Priority is tricky here, however, since there were two active proposals in the 1930s for machine translation: one in France by George Artsrouni, and a more elaborate one in the Soviet Union by Petr Smirnov-Troianskii. Both were largely ignored until the self-historicization of the field in the late 1950s. On Artsrouni, see W. J. Hutchins, *Machine Translation: Past, Present, Future* (Chichester: Ellis Horwood, 1986), 22–23. On Troianskii, John Hutchins and Evgenii Lovtskii, "Petr Petrovich Troyanskii (1894–1950): A Forgotten Pioneer of Mechanical Translation," *Machine Translation* 15 (2000): 187–221.

76. Quoted in Weaver, "Translation," 18. Despite the take-off of MT, consensus has sided with Wiener, since cryptography, being a map within the same language, is a poor analog to translation. See, for example, W. John Hutchins, "From First Conception to First Demonstration: The Nascent Years of Machine Translation, 1947–1954. A Chronology," *Machine Translation* 12, no. 3 (1997): 195–252, on 208; and Émile Delavenay, *La machine à traduire* (Paris: Presses universitaires de France, 1963), 16–17.

77. Quoted in A. Donald Booth and William N. Locke, "Historical Introduction," in Locke and Booth, eds., *Machine Translation of Languages* (1955), 1–14, on 4.

78. For the program, see "M.I.T. Conference on Mechanical Translation, June 17—June 20, 1952 Program," MIT Archives, AC359, Box 2, Folder: "Machine Translation Conf.-1952." This conference immediately followed one on electronic speech analysis, the other technological-linguistic hybrid that occupied MIT's marginalized Department of Modern Languages during the 1950s.

79. Bar-Hillel, "Some Linguistic Problems Connected with Machine Translation," *Philosophy of Science* 20, no. 3 (July 1953): 217–225; idem, "Machine Translation," *Computers and Automation* 2, no. 5 (July 1953): 1–6; idem, "Can Translation Be Mechanized?," *American Scientist* 42, no. 2 (April 1954): 248–260; and idem, "The Present State of Research on Mechanical Translation," *American Documentation* 2, no. 4 (1951): 229–237.

80. Léon Dostert, "Development Plan for the Institute of Languages and Linguistics, 1953–1958," 31 December 1952, GUA-SLL 1:1952.

81. Rev. Cyprian Towney to Dostert, 4 January 1955, GUA-SLL 1:1955; Robert Emmett Curran, *A History of Georgetown University*, 3 v. (Washington, DC: Georgetown University Press, 2010), II: 349–350.

82. A. C. Reynolds, Jr., "The Conference on Mechanical Translation Held at M.I.T., June 17–20, 1952," *Mechanical Translation* 1, no. 3 (December 1954): 47–55, on 48.

83. Dostert, "The Georgetown-I.B.M. Experiment," in Locke and Booth, eds., *Machine Translation of Languages* (1955): 124–135, on 125.

84. Erwin Reifler, "The First Conference on Mechanical Translation," *Mechanical Translation* 1, no. 2 (August 1954): 23–32, on 27, 31 (quotation).

85. Erwin Reifler, "The Mechanical Determination of Meaning," in Locke and Booth, eds., *Machine Translation of Languages* (1955): 136–164, on 136.

86. Victor A. Oswald, Jr., and Stuart L. Fletcher, Jr., "Proposals for the Mechanical Resolution of German Syntax Patterns," *Modern Languages Forum* 36, no. 3–4 (1951): 81–104.

87. Kenneth Harper, "The Mechanical Translation of Russian: A Preliminary Study," *Modern Language Forum* 38, no. 3–4 (1953): 12–29, on 12. For the Soviet view

of the same issue, see I. K. Belskaja, "Machine Translation of Languages," *Research* 10 (1957): 383–389, on 383.

88. Kenneth E. Harper, "A Preliminary Study of Russian," in Locke and Booth, eds., *Machine Translation of Languages* (1955): 66–85, on 67 and 69.

89. Regrettably, we have no detailed description of how the experiment actually worked, much less a copy of the computer code. The closest we come is Paul Garvin's April 1953 articulation of his plan of attack: "Statement of Opinion Concerning Machine Translation," 14 April 1953, GUA-MTP. The lack of public specificity was a source of frustration to contemporaries who wished to replicate the experiment or at least compare the results with other ventures, as described in L. Brandwood, "Previous Experiments in Mechanical Translation," *Babel* 2, no. 3 (October 1956): 125–127. Historical accounts must rely on the rather vague presentation in Dostert, "The Georgetown-I.B.M. Experiment," and the more technical but retrospective 1967 presentation by Garvin, "The Georgetown-IBM Experiment of 1954: An Evaluation in Retrospect," in Austin, ed., *Papers in Linguistics in Honor of Léon Dostert* (1967), 46–56. The best available reconstruction (although still speculative) is Hutchins, "The First Public Demonstration of Machine Translation."

90. Dostert, "An Experiment in Mechanical Translation: Aspects of the General Problem," August 1954, GUA-SLL 1:7–12/1954, p. 7. A slightly amended version of this description can be found in "The Georgetown-I.B.M. Experiment," 127.

91. Peter Sheridan, "Research in Language Translation on the IBM Type 701," *IBM Technical Newsletter* 9 (1955): 5–24, on 5. See also Garvin, "The Georgetown-IBM Experiment of 1954," 50.

92. For an explanation and survey of the various approaches in this period through the 1970s, see Jonathan Slocum, "A Survey of Machine Translation: Its History, Current Status, and Future Prospects," *Computational Linguistics* 11, no. 1 (January-March 1985): 1–17.

93. Sheridan, "Research in Language Translation on the IBM Type 701," 17.

94. Michael Zarechnak, "The Early Days of GAT-SLC," in Hutchins, ed., *Early Years in Machine Translation* (2000): 111–128, on 112; and Zarechnak, "The History of Machine Translation," 24.

95. Undated 2-page typescript, entitled "A Sample of Russian Sentences translated by the IBM Type-701 Data Processing Machines, together with the English translations," GUA-SLL 1:1–6/1954.

96. Léon E. Dostert to Director of the Mathematical Sciences Division at the office of the Chief of Naval Research, 25 May 1954, GUA-SLL 1:1–6/1954; Rear Admiral and Navy Chief of Staff L. H. Frost to Edward B. Bunn SJ, 21 July 1954, GUA-SLL 1:7–12/1954.

97. L. E. Dostert, "Outline for Extension of Research on Mechanical Translation," 6 July 1954, GUA-SLL 1:7–12/1954.

98. Paul W. Howerton to Dostert, 26 January 1954, GUA-MTP.

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100. Anthony G. Oettinger, "A Study for the Design of an Automatic Dictionary" (PhD dissertation, Harvard University, 1954).

Chapter Nine

1. Evgenii Zamiatin, "O literature, revoliutsii, entropii i o prochem [1923]," *Izbrannye proizvedeniia* (Moscow: Sovetskaia Rossiia, 1990), 434.

2. V. P. Berkov and B. A. Ershov, "O popytkakh mashinnogo perevoda," *Voprosy iazykoznaniia*, no. 6 (November-December 1955): 145–148. On the visit to New York, see Cuthbert C. Hurd, "Computer Development at IBM," in N. Metropolis, J. Howlett, and Gian-Carlo Rota, eds., *A History of Computing in the Twentieth Century: A Collection of Essays* (New York: Academic Press, 1980): 389–418, on 406. On the work of Liapunov's group, see Olga S. Kulagina, "Pioneering MT in the Soviet Union," in W. John Hutchins, ed., *Early Years in Machine Translation: Memoirs and Biographies of Pioneers* (Amsterdam: John Benjamins, 2000): 197–204, on 197. On Soviet cybernetics and Liapunov, see Slava Gerovitch, *From Newspeak to Cyberspeak: A History of Soviet Cybernetics* (Cambridge, MA: MIT Press, 2002).

3. D. Panov, I. Mukhin, and I. Bel'skaia, "Mashina perevodit s odnogo iazyka na drugoi," *Pravda*, no. 22 (13685) (22 January 1956): 4.

4. Yehoshua Bar-Hillel, *Language and Information: Selected Essays on Their Theory and Application* (Reading, MA: Addison-Wesley, 1964), 181. For surveys of Soviet research in this period, see I. K. Belskaja, "Machine Translation of Languages," *Research* 10 (1957): 383–389; Anthony G. Oettinger, "A Survey of Soviet Work on Automatic Translation," *Mechanical Translation* 5, no. 3 (December 1958): 101–110; V. Yu. Rozentsveig, "The Work on Machine Translation in the Soviet Union: Fourth International Congress of Slavicists Reports, Sept. 1958," tr. Lew R. Micklesen, *Machine Translation* 5, no. 1 (July 1958): 95–100; and W. J. Hutchins, *Machine Translation: Past, Present, Future* (Chichester: Ellis Horwood, 1986), chapter 6. The Soviets preferred calling the field "automatic translation," as discussed in I. A. Mel'chuk and R. D. Ravich, *Avtomaticheskii perevod, 1949–1963: Kritiko-bibliograficheskii spravochnik* (Moscow: VINITI, 1967), 5.

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8. Oettinger, "Machine Translation at Harvard," in Hutchins, ed., *Early Years in Machine Translation* (2000): 73–86, on 80.

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10. Michael Zarechnak, "The Early Days of GAT-SLC," in Hutchins, ed., *Early Years in Machine Translation* (2000): 111–128, on 113.

11. L. E. Dostert to Alberto Thompson, 17 April 1956, GUA-SLL 1:1–4/1956. Emphasis in original.

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13. Muriel Vasconcellos, "The Georgetown Project and Léon Dostert: Recollections of a Young Assistant," in Hutchins, ed., *Early Years in Machine Translation* (2000): 87–96, on 88. See the year-by-year breakdown by funding agency and scholarly institution in Automatic Language Processing Advisory Committee (hereafter ALPAC), *Language and Machines: Computers in Translation and Linguistics* (Washington, DC: National Academy of Sciences, National Research Council, 1966), 107–110; and R. Ross Macdonald, *General Report, 1952–1963* (Washington, DC: Georgetown University Machine Translation Research Project, 1963), v. On publicity, see "Machine Translation Tests Are Sponsored by CIA," *Georgetown Record* 11, no. 4 (January 1962): 1.

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18. Dr. S. Glazer, "Article Requirements of Plural Nouns in Russian Chemistry Texts," Seminar Work Paper MT-42, 1957, GUA-MTP.

19. Dostert, "Georgetown University Machine Translation Project: Proposal for Extension and Expansion of Research, 1961–1962," 1 December 1959, GUA-SLL 1:1959; Macdonald, *General Report*, 212; Brown, "Machine Translation," 131–132.

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31. Department of Scientific and Industrial Research, *Scientific and Technical Information in the Soviet Union: Report of the D.S.I.R.–Aslib Delegation to Moscow and Leningrad, 7th–24th June, 1963* (London: DSIR, 1964), 4. On VINITI's history and activities, see A. I. Mikhailov, A. I. Chernyi, and R. S. Giliarevskii, *Osnovy nauchnoi informatsii* (Moscow: Nauka, 1965), 7; A. I. Mikhailov, ed., *Izdaniia VINITI za 15 let, 1952–1966: Bibliograficheskii ukazatel'* (Moscow: VINITI, 1969); and A. I. Chernyi, *Vserossiiskii institut nauchnoi i tekhnicheskoi informatsii: 50 let sluzheniia nauke* (Moscow: VINITI, 2005). On the offset prints, see Boris I. Gorokhoff, *Providing U.S. Scientists with Soviet Scientific Information*, rev. ed. (Washington, DC: Publications Office of the NSF, 1962), 11; and Emilio Segrè, "What's Science Like in Russia?," *Chemical & Engineering News* (20 August 1956): 4058–4066, on 4060.

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56. Dwight Gray, notes on a conversation with E. J. Crane, 9 November 1954, AIP, Barton Records 78:4.

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61. The archives are littered with discussions of this question. See, for example, Barton to Beyer, 16 December 1955; Barton to Beyer, D. Gray, M. Hamermesh, E. Hutchisson, V. Rojansky, W. Waterfall, and V. Weisskopf, 11 October 1955; V. Rojansky to Beyer, 12 October 1955; Morton Hamermesh to Beyer, 14 October 1955; Victor Weisskopf to Beyer, 13 October 1955; Beyer to Henry A. Barton, 7 October 1955, all in AIP, Barton Records, Box 59, Folder: "JETP Dr. R. T. Beyer"; Henry A. Barton, memorandum on "Soviet Physics—JETP," 23 September 1955, AIP, Hutchisson Records 13:34; and Ralph A. Sawyer to Alan T. Waterman, 11 October 1960, AIP, Hutchisson Records 13:38.

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67. Robert T. Beyer, "Hurdling the Language Barrier," *Physics Today* (January 1965): 46–52, on 48.

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69. Eugene Garfield, "'Cover-to-Cover' Translations of Soviet Journals—A Wrong 'Solution' of the Wrong Problem," in Garfield, *Essays of an Information Scientist*, 3 v. (Philadelphia: ISI Press, 1977–1980), I:334–335, on 334.

70. Phillips, "The Translation Problem in Science," 54.

71. Dostert, "Brief History of Machine Translation Research," 7.

72. Bar-Hillel, "The Present Status of Automatic Translation of Languages," *Advances in Computing* 1 (1960): 91–163, quotations on 109, 94, 135.

73. Bar-Hillel, "Machine Translation," *Computers and Automation* 2, no. 5 (July 1953): 1–6, on 1; idem, "The Present State of Research on Mechanical Translation," *American Documentation* 2, no. 4 (1951): 229–237, on 230.

74. Jonathan Slocum, "A Survey of Machine Translation: Its History, Current Status, and Future Prospects," *Computational Linguistics* 11, no. 1 (January-March 1985): 1–17, on 4.

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76. The evaluator's verdict: "In brief, the translation can be understood by a chemist thoroughly familiar with the subject under discussion. A competent chemist can, from a study of the chemical formulas, reconstruct many of the chemical terms which appear to be a cross between a translation and a transliteration." Quoted in US House of Representatives, *Research on Mechanical Translation*, 48.

77. Vasconcellos, "The Georgetown Project and Léon Dostert," 94–95.

78. Ross Macdonald assumed control of the Georgetown program, and it was reintegrated with the Institute of Languages and Literatures. "MT Research at Georgetown," *Finite String* 2, no. 6 (June 1965): 4.

79. Léon Dostert, "Machine Translation and Automatic Data Processing," in Paul W. Howerton and David C. Weeks, eds., *Vistas in Information Handling, Volume 1: The Augmentation of Man's Intellect by Machine* (Washington, DC: Spartan Books, 1963): 92–110, on 94. Emphasis in original.

80. ALPAC, *Language and Machines*, quotations on iii, 16, and 23–24.

81. Kay, "Automatic Translation of Natural Languages"; Slocum, "A Survey of Machine Translation," 1. See also Michael Zarechnak, "The History of Machine Translation," in Henisz-Dostert, Macdonald, and Zarechnak, *Machine Translation* (1979): 1–87, on 57, 86.

82. Locke, "Machine Translation," 137.

83. Mel'čuk, "Machine Translation and Formal Linguistics in the USSR," in Hutchins, ed., *Early Years in Machine Translation* (2000): 204–226, on 221. On the negative international ramifications of ALPAC, which seemed to exclude only France, see Hutchins, *Machine Translation*, 167.

84. Elmer Hutchisson to Members of the Advisory Committee on Russian Translation, 27 December 1955, AIP, Hutchisson Records 13:34.

85. Wallace Waterfall to Robert Beyer, 9 August 1956, AIP, Hutchisson Records 13:30.

86. Coleman, "The Mass Production of Translation," 26–27.

87. Beyer to Waterfall, 15 November 1965, AIP, Koch Records 51:32.

88. Beyer to Waterfall, 16 February 1966, AIP, Koch Records 51:32; Rangra, "A Study of Cover to Cover English Translations of Russian Scientific and Technical Journals," 9.

89. Tybulewicz, "Cover-to-Cover Translations of Soviet Scientific Journals," 57.

90. Rangra, "A Study of Cover to Cover English Translations of Russian Scientific and Technical Journals," 8; Alice Frank, "Translations of Russian Scientific and Technical Literature in Western Countries," *Revue de la documentation* 28, no. 2 (1961): 47–51, on 48.

91. NSF, *Tenth Annual Report for the Fiscal Year Ended June 30, 1960* (Washington, DC: US Government Printing Office, 1960), 120–121.

92. Quoted in "Hurdling the Language Barrier," 5158.

93. Beyer, "Hurdling the Language Barrier," 48, 50.

94. Vannevar Bush, *Science: The Endless Frontier* (Washington, DC: Government Printing Office, 1945), 114.

Chapter Ten

1. Hermann Hesse, *Das Glasperlenspiel* (Frankfurt: Suhrkamp Verlag, 1963 [1943]), 324.

2. Franz Thierfelder, *Die deutsche Sprache im Ausland*, 2 v. (Hamburg: R. v. Decker, 1956–1957), I:114.

3. Michael Balfour, "Four-Power Control in Germany 1945–1946," in Balfour and John Mair, *Four-Power Control in Germany and Austria, 1945–1946* (London: Oxford University Press, 1956), 46.

4. Norman M. Naimark, *The Russians in Germany: A History of the Soviet Zone of Occupation, 1945–1949* (Cambridge, MA: Belknap, 1995), 20–21.

5. Balfour, "Four-Power Control in Germany 1945–1946," 74–75.

6. Balfour, "Four-Power Control in Germany 1945–1946," 109–110.

7. Naimark, *The Russians in Germany*, 39–41.

8. Max von Laue, "A Report on the State of Physics in Germany," *American Journal of Physics* 17 (1949): 137–141.

9. R. C. Evans, "Naturforschung in Deutschland," *Physikalische Blätter* 3, no. 1 (1947): 12–14, on 12.

10. Klaus Hentschel, *The Mental Aftermath: The Mentality of German Physicists, 1945–1949*, tr. Ann M. Hentschel (New York: Oxford University Press, 2007).

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12. Thierfelder, *Die deutsche Sprache im Ausland*, I:7, II:37. Bulgaria was still using German as a leading language of science well into the Cold War. See ibid.: II:22.

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14. James F. Tent, *Mission on the Rhine: Reeducation and Denazification in American-Occupied Germany* (Chicago: University of Chicago Press, 1982), 40.

15. John Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe* (Cambridge, MA: MIT Press, 2006), passim, but especially 35, 65, and 109–112.

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17. Naimark, *The Russians in Germany*, 441–443; John Connelly, *Captive University: The Sovietization of East German, Czech, and Polish Higher Education, 1945–1956* (Chapel Hill: University of North Carolina Press, 2000), 203.

18. Falk Pingel, "Attempts at University Reform in the British Zone," tr. David Phillips and Alison Goodall, in David Phillips, ed., *German Universities after the Sur-*

render: British Occupation Policy and the Control of Higher Education (Oxford: University of Oxford Department of Educational Studies, 1983), 20–27, on 22.

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20. David Phillips, "The Re-opening of Universities in the British Zone: The Problem of Nationalism and Student Admissions," in Phillips, ed., *German Universities after the Surrender* (1983): 4–19, on 4.

21. Tent, *Mission on the Rhine*, 238, 247–249, 299.

22. Minutes of the 97th Faculty Meeting, 21 November 1959, FUA, MatNatFak 2.6, Fak.-Protokolle (1959), 395.

23. "Promotionsordnung der Mathematisch-Naturwissenschaftlichen Fakultät der Freien Universität Berlin," 18 January 1953, FUA, MatNatFak 2.6, Fak.-Protokolle (1953), paragraph 12.

24. Edward Hartshorne to his wife, 28 September 1945, reproduced in James F. Tent, ed., *Academic Proconsul: Harvard Sociologist Edward Y. Hartshorne and the Reopening of German Universities 1945–1946* (Trier: Wissenschaftlicher Verlag Trier, 1998), 128.

25. Ernst Brücke, "Ost und West," *Physikalische Blätter*, no. 5 (1948): 224.

26. Mark Walker, "The German Physical Society under National Socialism in Context," in Dieter Hoffmann and Mark Walker, eds., *The German Physical Society in the Third Reich: Physicists between Autonomy and Accommodation*, tr. Ann M. Hentschel (Cambridge: Cambridge University Press, 2012 [2007]): 1–21, on 19.

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28. Hentschel, *The Mental Aftermath*, 31. The Americans and British also heavily subsidized the purchase of German translation rights for English-language material, paid for using occupation currencies, which provided a substantial boost for West German publishing. See Balfour, "Four-Power Control in Germany 1945–1946," 224.

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30. On the Soviets' conflicted relationship toward East German science, see Dolores L. Augustine, *Red Prometheus: Engineering and Dictatorship in East Germany, 1945–1990* (Cambridge, MA: MIT Press, 2007), 144.

31. Connelly, *Captive University*, 40.

32. Raymond G. Stokes, "Chemistry and the Chemical Industry under Socialism," in Kristie Macrakis and Dieter Hoffmann, eds., *Science under Socialism: East Germany in Comparative Perspective* (Cambridge, MA: Harvard University Press, 1999): 199–211.

33. On the upheavals in Soviet education, see Michael David-Fox, *Revolution of the Mind: Higher Learning among the Bolsheviks, 1918–1929* (Ithaca: Cornell University Press, 1997).

34. Connelly, *Captive University*, 62.

35. Naimark, *The Russians in Germany*, 234; Peter Nötzoldt, "From German Academy of Sciences to Socialist Research Academy," tr. Thomas Dunlap, in Macrakis and Hoffmann, eds., *Science under Socialism* (1999): 140–157, figures on 140.

36. Eckart Förtsch, "Science, Higher Education, and Technology Policy," tr. Deborah Lucas Schneider, in Macrakis and Hoffmann, eds., *Science under Socialism* (1999): 25–43, on 32.

37. Connelly, *Captive University*, 42, 51.

38. Augustine, *Red Prometheus*, 174.

39. Kristie Macrakis, "Espionage and Technology Transfer in the Quest for Scientific-Technical Prowess," in Macrakis and Hoffmann, eds., *Science under Socialism* (1999): 82–121, on 83–84.

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phasis in the original. Mathematics and Chemistry were particularly emphatic about the importance of Russian for keeping abreast of the scholarly literature (ibid., 103).

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