Chemical Transformations: Translation and the Periodic Table in Japan

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Science and Language

Since its very beginnings, scientific knowledge has resided largely in the deposits of language. It is the written word, above all, that has allowed science to be recorded, shared, debated, standardized, passed on, and advanced. We know this, intuitively, whether we are students of the ancient manuscript or the contemporary journal. Prior to very recent times, in fact, the forms of learning we would recognize as scientific existed almost entirely in texts: science largely began and ended with inscription. Certainly there were practices involved too: in chemistry, with its alchemical past, procedures for combining and mixing of materials had to be learned, usually through demonstration and apprenticeship, and sometimes in secret. Yet none of this could have survived unless written down and studied in some way. Much depended on various crucial works, it appears, such as the *The Emerald Tablet of Hermes* (and its many versions), the Arabic *Kitab Sirr al-Asar* (Book of Secrets), or even Pliny's *Natural History.* Moreover, as we approach the modern era, with its dependence on the technology of print, the epochal work of thinkers such as Paracelsus, Boyle, and Lavoisier gained great influence by being published and—most of all—disseminated to other natural philosophers in other lands.

Scientific Translations

Once embodied in writing, knowledge becomes mobile. We say that science "advances", but it also moves, across borders of time and place, as a result of being transferred from one people and language to another. Indeed, movements of scientific knowledge have been central to the building of modern societies—we need only think of the effects brought about by the introduction into various cultures of Archimedean mechanics, Arabic (actually Indian) numerals, the calculus, the periodic table.

How is knowledge made mobile, and thereby accessible to the greater world? Above all, through the work of translation. No less than his literary counterpart, the scientific translator has been the creator of new texts, the multiplier of sources into new languages, and thereby the producer of new "originals" for use. Indeed, when viewed in this way, scientific translation becomes far more than the silent, word-for-word chiseling of anonymous scriveners or technical "clerics"—the impoverished image so often given to this effort. In fact, over the centuries, translation has increased the great library of science many times over, and it has done this in manifold and diverse ways. Prior to the 20th century, as it happens, there were no set standards at all for how translators should perform their task or how accurate their results should be. The rendering of scientific works into new languages sometimes strove for fidelity, sometimes paraphrase, most often a mixture of the two. It employed both oral and written methods, often together. It involved individuals, families, even teams. It used for its sources original texts, edited and re-written texts, fabricated or falsely attributed texts, works already translated several or more times, works of recent vintage or those more than a thousand years old that had long ceased to exist in anything resembling their first form. As a result of all this diversity in method and material, translations of scientific works varied enormously in their quality and character. Close inspection shows that any single translation varied significantly in the degree to which it remained loyal or re-wrote an original, a variability that depended on the exact nature of the text, the knowledge and ability of the translator, and so on.

Thus, in order to accept and understand translation as a crucial historical force in science, we must also admit the rich complexities that have long surrounded it. Moreover, though it remains all to common too conceive of scientific translation as literal, mechanical work, this has never been true. Indeed, the image is a form of prejudice. Experienced (and honest) translators of scientific works today would be forced to admit that their work is more complex than simple lexical transfer. Translating science cannot avoid the responsibility of interpretation, the re-making of an original. As linguists and literary theorists have frequently pointed out, there is never a one-to-one correspondence among languages, even among those of a single "family" (e.g. the Romance languages). If there were, no use whatsoever would exist for the living, breathing translator of today: machines would have long rendered him extinct. Of course, auto-translation remains very much a dream of the present. But as anyone knows who has examined (or been forced to edit) current results in this area, it still has a long way to go; the element of interpretation cannot be wished away, algorithmically.

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  1433-7851/02/4105-0739 $ 17.50+.50/0

Introduction of Chemistry in Japan

What about historical examples, then, of how translation has worked its effects? Chemistry, in fact, provides some of the most intriguing examples. Consider, for instance, the way in which modern chemical concepts, the idea of "element" and the entire nomenclature of the periodic table, came to make their appearance in a distinctly non-western nation, in an assertively non-western language.

Between roughly 1780 and 1850, a great measure of European science, including the new chemical principles inaugurated by Lavoisier, was transferred to the island of Japan. This was a period in which those whom we might term scientists in Japan were translators above all else—such was their primary, and often their only, work. Moreover, they were translators from the Dutch—*rangaku-sha* ("scholars of Dutch Studies"). Holland, after all, remained at this time the only European nation with which Japan allowed any trade relations, and it was through Dutch translations of many English, French, Latin, and German works that Japan learned of western science. A ban on books from Europe had been lifted in 1720, and these had begun to be translated not long after. By the later decades of the 18^{th} century, some of these translated works—specifically those on medicine—had begun to be published and made available to the scholarly community, with the result that a surge of interest in European science occurred.

In chemistry, as in other fields, there was no possibility of a simple transfer in vocabulary from western languages to Japanese or Chinese (still the language of high scholarship in Japan during this period). Many fundamental ideas and terms, including those for "element" and "chemistry", as well as the names for many elements themselves, had to be invented, debated, and eventually accepted. No linguistic models or guides in Japanese existed for this sort of mass transfer. Instead, the responsibility fell upon the shoulders of the individual translator.

The person who took on this profound task was Yoan Udagawa, a brilliant polymath of indefatigable curiosity, energy, and productivity.[1] Between 1820 and 1850, he produced a seminal 20-volume work on chemistry, the *Seimi Kaisō* ("Principles of Western Chemistry"), as well as books on occidental botany, zoology, history, geography, music, and mathematics. Udagawa came from a well-known family of physician–scholars trained in Chinese medicine (as were all Japanese physicians), and was led to an interest in western chemistry by two streams of influence, one ancient, the other contemporary. As a physician, Yoan had been educated in classical, herbal-based therapies and had a deep appreciation for pharmacology. His adopted father, meanwhile, was a *rangaku-sha*, contracted by the government to help translate the new books then coming from Holland, and keenly aware, it seems, of his son's linguistic and intellectual abilities. Yoan was thus urged to master both the Chinese classics and the Dutch language, in order to be in a better position to weigh each against the other and also to present the new western science in a manner palatable to other Japanese scholars. As a young man with both conservative roots and larger ambitions, Yoan Udagawa found himself at a historical cross-roads. It was his fate, in a sense, to contribute magnificently to the growing shift away from traditional natural philosophy, with its ancient Chinese roots, and toward a more modern, materialist science.

The *Seimi Kaisō* was a foundational work of this new science for several reasons. First, it introduced element theory, related terminology, and Lavoisieran chemistry in general. Second, it was written not in Chinese, as scholarly books commonly were up to that time, but in the native tongue, Japanese, and in a style very much intended to be accessible to the entire literate community. Third, in creating a new terminology, including the names of the elements, it did not do away entirely with pre-existing titles, such as those for important and well-known metals (gold, lead, copper, silver), but instead incorporated these into a complex and diverse system of nomenclature that even made certain concessions to Chinese natural philosophy.

What were Yoan's actual sources? There appear to have been a fair number of them, perhaps as many as 20 separate books,[2] from which Yoan translated sections, paraphrased others, and assembled individual chapters of his own work from these various selected pieces. The most important text he used seems to have been a Dutch work of complicated history. In simplified terms, it was a Dutch translation of a German work, *Chemie für Dilletanten* (1803), which was itself translated from William Henry's *Epitome of Chemistry* (1803), a very successful English rendering, in paraphrased form, of Lavoisier's own *Traité* Elementaire de Chimie (1789). Yoan's choice was therefore well-considered, even as a translation of a translation of a paraphrased translation.

The Periodic Table in Japanese

What, then, of his terminology? In what form did the modern elements appear in Japan? The *Seimi Kaisō* lays out a clear definition of "element", calling it a "primitive indivisible substance". The word the author used for this basic substance was *genso*, a combination of two ideograms, the first of which meant "origin/beginning," the second, "simple/essence". This choice seems to have been partly a nod in the direction of Chinese natural philosophy, with its emphasis on fundamental ontological principles. But Yoan's employ of the character *so* ("simple/essence") was also a potent adaptation. Indeed, in a fair number of element names, he used this ideogram as a suffix for elements that did not exist in Japanese or Chinese: for example, *suiso*, or "water-essence", for hydrogen; *tanso*, or "coal-essence", for carbon, and also (an interesting historical touch), *onso*, "warmth-essence", for the false element "calorium" proposed by Berzelius but later rejected by European chemists. The adaptation of this form comes from the Dutch/German tradition of element names, a tradition that included *Grondstoff/Urstoff* for "element" (and *Koolstoff/Kohlenstoff* for "carbon", etc.) and that, for a variety of reasons, political in part, was never replaced with the new French nomenclature invented by Lavoisier. As a *rangaku-sha*, a student of Dutch Studies, Yoan Udagawa was also an inheritor of this terminological tradition: in entering Japan, European science was very often forced to pass through the filter of Dutch linguistic realities.

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The full nomenclature of the *Seimi Kaisō*, however, was far more complex and "multicultural" than this might suggest. In total, the kinds of titles included the following: 1) traditional Japanese names, using one ideogram (e.g. *kin* for gold), that had originally come from the Chinese; 2) Japanese names with two or more characters, that were native in origin; 3) literal translations from the Dutch, e.g. *hakkin* ("white-gold") for *witgout* (platinum); 4) translations using the suffix *so*; 5) names phonetically translated from the Latin (which had been retained in Dutch), using a sound system that had been adapted from the Chinese centuries earlier (one that employed ideograms purely for phonetic value). In total, therefore, Yoan's nomenclature was both faithful to the preeminence of Chinese linguistic influence in Japan and also innovative in introducing new methods of naming that extended well beyond the reach of such influence.

This overall scheme, however complex, was not the final word in chemical nomenclature. Yoan had helped set a new pace, and with the opening of Japan in general to works from other nations, the terminology he inaugurated was sure to undergo some modification later on. Indeed, during the later half of the 19th century, chemical nomenclature was the subject of no small debate, with several major new schemes proposed, some loyal to ancient tradition, others to Western usage, and still others endeavoring to replace everything that had gone before with a set of new Japanese names, written purely in Japanese script (*hiragana*). Even the title for "chemistry" itself—previously (as in *Seimi Kaisō*) given as *seimi,* a phonetic adaptation from the Dutch (*Schemie*)—was fought over and eventually replaced with the word *kagaku* ("study of change"), a Chinese loan-word. Above all, however, influence from Europe remained strong—much of Yoan Udagawa's terminology was kept intact—particularly with the influx of new works on chemistry translated from English, French, and German. Element names taken from these languages were increasingly changed from the Chinese-inspired sound system to another phonetic script native to Japan (*katakana*). Between 1880 and 1950, one sees a fascinating shift in nomenclatural favoritism aimed, first, at lingering Dutch and Latin influences, then German (to about 1920), and finally English[3]—reflecting, in no small part, changes in perception regarding scientific preeminence and also political power worldwide.

Today, in other words, the periodic table in Japanese is a magnificent litmus of history—a chart of translated adaptation that includes ingredients from Asia and Europe both. Ancient Chinese, 17th century Latin, 18th century Japanese, and 20th century English sit shoulder-to-shoulder in this terminological dais. A testament to ingenuity, practicality, and also socio-political vulnerability, the formation of the elements in Japan is also an excellent example of how translation, as a historical process, has helped contour the scientific world of the present.

An Increased Role for the Present-Day Translator of Science

What of today, then? Such historical examples certainly have their fascinating (and too often overlooked) place in understanding the roots of modern science, but what of the contemporary scene? Has translation a continued role, indeed a central one, in the present and future of science? After all, hasn't English achieved a clear, dominating role as the *lingua franca* of technical communication? Haven't scientists themselves been enormously mobile beginning in the 20th century, changing countries and languages on a large scale, whether urged by political or other circumstances? To what degree has this type of internationalization of science affected the place and importance of translation?

In fact, the role of translation is more crucial today than ever before, in part due to these very phenomena of the contemporary historical moment in science. For instance, the routine claim for a dominance of scientific English actually disguises a number of realities that have immediate implications for translating work. One of these is the truth that a great deal of science continues to be published in native languages—especially where research has a nationalistic importance or utilizes materials of local origin (China, Japan, Russia are strong examples)—a situation that results in more than one tongue being used in a particular country to publish primary science, thus creating a need for translators (the idea that scientists everywhere will renounce their mother tongues *entirely* to perform science seems naïve, particularly given the political context within which research and publication often take place). Certainly, the major portion of the secondary literature in any country is published in that nation's language. Moreover, in cases where English is the destination language for publication, scientists in many non-English speaking nations do much (or all) of their primary research in their mother tongue and then translate (or have translated) their results into English for submission. In other words, the "dominance" of English imposes an *increased* need for translation.

English—the Lingua Franca of Science?

The international preference for English, furthermore, is also not the same for all fields; in certain disciplines (e.g. physics) it is strong, while in others (geology) it is much more variable. Finally (but this is hardly a complete list of relevant phenomena), the English used for scientific publication is not at all universal, but comes in a number of different forms—indeed, linguists today speak not of "world English" at all but of "world Englishes". Grammar, lexical structure, terminology, and syntax exhibit no small amount of variability between journals published in India, Hong Kong, Singapore, and the U.S. As an international language, English has inevitably been adapted to different cultural-linguistic settings, and science has very much been a part of this. In brief, there is no single, standard "scientific English"; nor is there likely to be any, since this speech is itself often a subset of the English spoken or used as a professional language in different settings. To wish for such a standard is to hope for the assumption of artifice, indeed to desire an erasure of all culture from the land of science. Linguistic variability in a global language is as inescapable as changes in climate.

Let us not ignore, either, the vast area—and deep importance—of communicating research to non-scientists, including the public, the mass media, educators, political leaders, and other decision-makers. Unless all nations of the world agree to abandon their own languages and linguistic traditions, it seems likely that translation will continue to command considerable significance in the transfer of knowledge here too. On the other hand, there are the realities of corporate science, involving patents, manuals and other documentation, reports, "white papers", and so forth, all of which are regularly produced for specific clients and thus in a wide array of languages.

For all these reasons, the technical translator—however invisibly—is more important than ever before, a mobilizer of scientific information on a daily, even hourly basis. Only when all nations of the world decide to abandon their own forms of speech and adopt a single, universal standard will this situation change. Is this something to wish for? But then our desire would aim at an enterprise that had left the human dimension to intelligence behind.

[1] S. L. Montgomery, *Science in Translation: Movements of Knowledge through Cultures and Time*, University of Chicago Press, Chicago, **2000**.
[2] M. Tanaka, *Jpn. Stud. Hist. Sci.* **1976**, *15*, 97–109.
[3] K. Sugawara, K. Itakura, *Kagakushi Kenkyu* **1990**, *29*(175), 193–202.

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