LOCAL TO GLOBAL: EDUCATIONAL CIRCULATION

The circulation of knowledge in the physical sciences during the twentieth century

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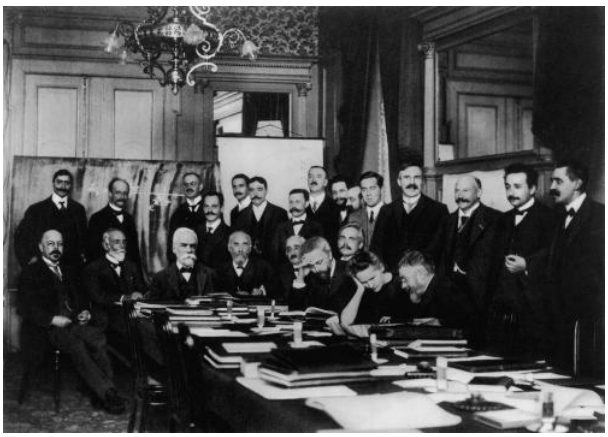
ABSTRACT

The circulation of knowledge is a major aspect of the physical sciences, which are caught between ambitions of universality and the constraints of both experimentation and written communication. A European space of personal relations, correspondence, publications, and institutions emerged over the long term beginning in the late sixteenth century, reaching its height at the very end of the nineteenth century. The group formed by elite physicists, chemists, astronomers, and mechanics saw themselves as resolutely international and internationalist. However, the First World War sparked a "national shift," as national communities developed during the interwar period all while turning inward. The Second World War had radically different consequences, as the massive migration of Eastern European scientists toward the West, including the United States, in addition to the role played by these émigrés in the actual outcome of the conflict, led to a new internationalization that henceforth concerns all scientists.



Participants in the First Solvay Congress on Quantum Mechanics in 1911.
Photograph taken by Benjamin Couprie for the Institut international de physique Solvay, Leopold Park, Brussels, Belgium, November 2, 1911.

The sciences are one of the human activities that became internationalized very early on, as their productions, not

to mention those who practiced them, have circulated on a global and especially European level since at least the late sixteenth century. This was particularly true for what we refer to as the "physical sciences," which is to say a group of disciplines characterized by mathematization (or the perspective thereof) and an experimental dimension, namely physics, chemistry, astronomy, and mechanics. While experiments are always local, by necessity, the use of mathematics provides a common language that facilitates the normalization and circulation of knowledge, conceived of as a way to ensure the universalization (and hence a form of objectivization) of the result obtained. Since the time of René Descartes (1596-1650), practicing the physical sciences has meant being part of a Eurocentric network of peers, initially structured by correspondence and later by institutions (such as sciences academies) and publications: e.g., *Philosophical Transactions* and *Journal des sçavans* were created in 1665. However, paper technologies were not enough, and people had to circulate in order for knowledge to do so, given the extent to which the development of experimental arrangements involved tacit know-how that could be transmitted only through practice.

This internationality had its ups and downs, but reached its apex during the early twentieth century: from the 1890s to 1914, it was the basis for a scientific internationalism, which was established as a model for societies. The number of associations for intellectual cooperation skyrocketed, while the international congresses that appeared in the mid-nineteenth century increased. The Solvay councils, which were inaugurated in 1911, played a major role in structuring the theory of quanta by organizing the systematic transfer of knowledge. The creation of the Nobel Prize in 1901 occurred in the same context, with its symbolic position resulting from its international character, which was especially European given that 33 of the 35 prizes in physics and chemistry before 1915 were awarded to Europeans. This scientific international was based on a limited, elite, and elitist community: before 1914, nearly one third of active physicists took part in awarding the Nobel prize by serving either as presenters, nominated candidates, or decision-makers. The Swede Svante Arrhenius (1859-1927) played a major role in activating his personal network that extended across Europe. It was, in a sense, an international of individuals, limited to narrow circles of those who had proven themselves.

The First World War sparked a "national shift" that was quite evident in the physical sciences. The closing of national communities can of course be explained by the suspicion that now separated scientists on opposing sides: French chemists refused to have any contact with their German peers during the 1920s, especially with Fritz Haber (1868-1934), the "father of chemical weapons." The number of foreign students in European laboratories dropped sharply, especially in Germany, which before the war was the primary center for global science thanks to universities such as Göttingen. However, this closing off can also be explained by governments becoming aware of the usefulness of these sciences: circulations on the European scale became less essential intellectually as national communities developed and expanded thanks to the creation of dedicated organizations, such as the Department of Scientific and Industrial Research in the United Kingdom, the Kaiser Wilhelm Gesellschaft in Germany, the Consiglio Nazionale delle Ricerche in Italy, and the Caisse nationale des sciences in France. Another example is the development of publication activity, which remained highly national. In 1934, the *World List of Scientific Periodicals* included approximately 36,000 titles, as opposed to 1,400 during the 1860s, with approximately 13,500 in English, 6,100 in German, and 5,000 in French. Historians have thus defended, among others, the idea of a "French school" of physics during the interwar period, in which scientific debates took place much more among the French than across borders. As a matter of fact, the theory of relativity took hold only slowly, due to its "German origin."

The rise of Nazism in Germany sparked a forced renewal of international circulation, as numerous scientists fled persecution toward Western Europe, and the United States in particular; when they did not leave of their own accord, they were driven away through their exclusion from public service. Theoretical physics in particular was seen as "Jewish physics," as opposed to *"Deutsche Physik"*: Albert Einstein (1879-1955), whose home was ransacked by the SS, left Europe in the fall of 1933 and settled in Princeton. Actors such as the Rockefeller Foundation or the Society for the Protection of Science and Learning financed and organized the movement: all told, approximately 4,000 German academics lost their jobs, 1,700 of whom crossed the Atlantic. This migration

played a crucial role in the United States acquiring the status of a major scientific power: émigré scientists, who were highly oriented toward theoretical research, complemented the empirical perspectives of their American peers, and played an important role in the war effort, if only on the Manhattan Project with the role of the Hungarian Leó Szilárd (1898-1964).

The physical sciences showed what they were capable of in Hiroshima, with their role in Western societies growing exponentially. High energy physics, which involves massive equipment and financing, became the symbol of modernity. In order to compete with the United States, scientists from eleven governments united in 1952 to establish one of the first European institutions, CERN (European Organization for Nuclear Research). The circulation of researchers became a (geo)political and economic issue, given how much war had showed its effectiveness as a lever for research: the United States continued to attract “brains” (which prompted the first denunciations of a “brain drain” by the Royal Society in 1963), but in its concern to shield allies from temptation by the Soviets, it contributed to the revival of European networks via NATO’s Science Committee (North Atlantic Treaty Organization) and support for initiatives such as Les Houches School of Physics. New actors emerged in the publishing world by taking advantage of the German collapse and using international networks, especially Elsevier and North-Holland located in the Netherlands: in 1977, 93% of authors in chemistry journals published in Holland were from abroad, as opposed to 66% for British journals, 38% for US journals, and only 3% for West German ones. This re-internationalization, which involved all scientists, marked a uniformization of practices, which can be characterized by their “Americanization”: in 1960s Europe, a postdoctoral position in the United States became a common step in scientific careers, and in the 1980s it became unthinkable to publish in French or German.

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