Boundaries of Chemistry: Interest and Identity in Early Twentieth Century

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The relationship between chemistry and its neighbors can be studied from a science-policy point of view. From this latter aspect, the demarcation problem seems differently when looked at from the philosophy of science approach. Both policy and philosophy analyse the differences between science and non-science but their conclusions diverge. Similarly, chemistry's relationship with other sciences can be considered as a demarcation problem between chemistry and non-chemistry. This problem can also be analysed both from a philosophical and a policy point of view. The difference between these two approaches is demonstrated by two case studies: the discovery of hafnium and the first national congress of Hungarian chemists.

The philosophical approach

The philosophical approach raises the problem of defining chemistry as a field having its own identity. Philosophers provided various criteria for defining the identity of science aiming at demarcating science from non-science. Chemistry can be assumed to be defined by some criteria demarcating it from non-chemistry, such as physics, biology and other areas. Logical positivists applied various criteria like verification or testability. Thomas Kuhn relied on paradigms, Imre Lakatos on research programs, while Robert Merton on some ethical norms for defining science. All these approaches can be considered essentialist because they all tacitly assumed that chemistry can to be defined by some criteria that demarcate it from non-chemistry such as physics, biology and other areas. These approaches can be considered essentialist because they tacitly presuppose that there is something in the real word that distinguishes science from all other things, something that belongs to science, which is constant and does not change over time. This unchanging component is the essence of science. Since the essences of various representations sharply differ from each other, when defining

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the essence of science, we automatically demarcate science from all other representations.

Ironically, Karl Popper while attacking essentialism also took an essentialist stand himself. His hypothetico-deductive system was just as essentialist as the theories (Marxism and Freudism) that he opposed. Neither Popper, nor many other philosophers of science would be happy to be called essentialist because they fought against all kinds of metaphysics. Indeed, essentialism originates in Plato and Aristotle's philosophy, in their metaphysics or metaphysical presumptions but it became an important doctrine in the Thomist philosophy in the Middle Ages.

Essence of chemistry: the hafnium story

When thinking of chemistry as a distinct, unchanging form of scientific knowledge, which differs in principle from other forms, we are essentialists. We follow the logic of those who consider science as a distinct, constant form of representation. The debate over reductionism is connected to this view. Mary Jo Nye has summarised and analysed in detail the difficult relations between chemistry and physics in a historical perspective.[1] Without considering the debate over the late 18^{th} century chemistry about the role of the theory of heat or pneumatical physics in the chemical theory of combustion let us turn to the 20^{th} century. In some of their papers, Anna Simoes and Kostas Gavroglu discussed the problem that quantum chemistry raised the issue whether chemistry had been, in principle, but not in practice, reduced to physics right after Heitler and London published their seminal article in 1927.[2]

Karl Popper, however, came to the same conclusion even before the emergence of quantum chemistry in 1927. He wrote in his *Logic of Scientific Discovery* that "all attempts to find it (the chemical element with atomic number 72) were in vain until Bohr succeeded in predicting several of its properties by deducing them from his theory."[3] Popper also wrote that the discovery of hafnium "struck us then as the great moment when chemistry had been reduced to atomic theory."[4]

The discovery of hafnium was related to a collision between inorganic chemistry and Bohr's old quantum theory concerning the unknown chemical element number 72.[5] In 1911, George Urbain, a French expert of rare earth elements, believed he had found element 72 in a mineral called yttria by his method based on a 'separating element' that crystallised with rare earths. Urbain called the element, celtium. He thought that celtium was another rare earth to be placed in the row below the periodic table. Niels Bohr, on the other hand, concluded that the unknown element 72 should be a transition metal to be placed on the table, below zirconium. He based his view on the so-called old quantum theory, mainly his atomic model created in 1913 and articulated in the early 1920s. In 1922, relying on Bohr's theory, George Hevesy, a Hungarian chemist of Bohr's institute in Copenhagen with a young Dutch physicist, Dirk Coster found the element 72 in a Norwegian zirconium mineral. The element was subsequently called hafnium. Chemical investigations proved that hafnium was a transition metal, as Bohr predicted. Because of the exciting subsequent priority debate between Hevesy and Urbain, this story then became well known. Hevesy's victory, which brought him nominations to the chemistry Nobel Prize, can be attributed to Bohr's model. In his memoirs, Hevesy recognized the decisive role of Bohr's theory in his celebrated discovery.[6]

Nevertheless, was Popper right? Can the important contribution of the old quantum theory to the discovery of hafnium be considered as a reduction of chemistry to physics? Philosopher, Eric Scerri denied this in several publications. He argued against the Popperian view in two points. First, some chemists, including the Danish Thomsen, guessed, on purely chemical evidences, that element number 72 should be a zirconium homologue. Second, Bohr's model was not a physical theory deduced from first principles of physics; rather it was a strange mixture of inductive generalisations largely based on chemical experimental data.[7]

Whilst partly agreeing with Scerri's opinion, it is considered that both Popper's and Scerri's argumentation was essentialist. They, with other discussants of reductionism, assume that we have chemistry here, physics there, with different essential characteristics, and it can be decided whether a particular statement is connected to one or the other's essence. It is a metaphysical problem whether chemistry has its own essence or not, whether physics and chemistry are representations of two separate parts of nature or chemistry represents just a part of nature investigated by physics.

The policy approach: boundary work

Since the 1990s, a new approach to the demarcation problem has been developed inside studies of science and technology. Based on a social constructivist view, some authors looked at the problem of demarcation as a battlefield in a fight for more resources, influence and authority. Thomas Gieryn considered science as being a space on the map of the cognitive activities. In this space, science has an unquestioned cognitive authority. The map is divided between various activities, which have their own lands with boundaries. The lands are competing for enlarging or defending their boundaries. Science, as one of these lands, has vested interest to defend its boundaries against the attacks of non-science and to expand its boundaries by all legitimate means. This defending and expanding activity is called boundary work.[8]

The boundaries of science are not fixed. They are contingent, flexible, context-dependent and negotiable. This is a non-essentialist view, as it does not assume that science has an unchanging, fundamental difference from any other social institutions representing some cognitive authority, such as arts, politics, and business. Science becomes one of the many parties competing for cognitive authority, resources and social influence. In this competition, the boundaries of science are not fixed. Whether astrology or psychoanalysis is in a better position (to use a Popperian example) compared with astronomy or behaviorism depends on the actual state of the competition between the fields. Science has vested interest to defend its boundaries against the attacks of the other parties and it attempts to expand its boundaries by all legitimate means of the competition. In this approach, ideological debates, such as the debate over reductionism, can be considered normal processes of the boundary work.

This approach throws different light on the identity of chemistry. In the land of sciences, chemistry claims to have a part of its own. It has boundaries with neighboring fields, such as physics. Chemistry works at its boundaries that are attacked from various directions such as physics, environmentalist movements, agricultural interests, traditional medicine, and many others. Inside its boundaries, chemistry claims to have cognitive authority defined by the population of chemists. So, who are the chemists?

The first national congress of Hungarian chemists

From the problem of what chemistry is, now shift to the problem of who lives in the land of chemistry. This constituted a major practical issue in the chemical community in Hungary at the beginning of the 20th century. The problem was formulated in a letter sent to a journal of pharmacists in 1905: “Would you know, dear Mr. editor, to whom you are talking if he introduced himself as X. Y., chemist? You would not, would you? Because this man could well be an engineer graduated from a technological institute, or a chemist trained by an industrial school but he could also be a philosopher who learned some chemistry at the faculty of humanities, or a pharmacist, perhaps an assistant at a drug store, but he could also be just a dry cleaner. Depending on their taste, they all can call themselves chemists."[9]

The issue seemed so important at the time that a chemical engineer, editor of a journal of chemistry, Gyula Halmi, decided to discuss it at a conference. He started to organise the first national congress of Hungarian chemists that was finally held in 1910. The task of the congress was to discuss the common interests of chemists coming from divers areas of the field.

During the five years between publishing the above letter to the editor and the opening of the congress, a number of articles and letters appeared in the Hungarian chemistry journals on the identity of chemists. The pharmacists were particularly active. According to an article, pharmacists and those chemists, who graduated at the faculty of humanities should be expelled from industry because their theoretical and practical training were of a low level.[10] The reply was published in a journal of pharmacists. It argued that the chemistry training of the pharmacists was good enough for occupying jobs in drug stores, and for enabling them to develop into very good chemists. The argument was supported by a list of some leading chemists of the country who were originally trained as pharmacists. In 1907, an author explained that the chemistry training available in Hungary included the pharmaceutical schools, faculty of humanities, Technical University, and industrial schools. In industry, only those people should be employed, he said, who are trained in industrial schools or at the Technical University. He concluded that the good chemists were the chemical engineers.[11] Someone else reported that a war was breaking out between the chemical engineers and the industrial school graduates. Earlier, factory positions were despised as non-gentleman occupations for someone having a university degree because the working hours were long and the industrial plants were dirty. Now, he said, unemployment had changed this judgement.

The debate went on in the same tone for years. A group of chemists wanted to exclude some other groups from the field of chemistry. In other words, they wanted to defend their territory by narrowing and strengthening the boundaries of chemistry. The boundary work intending to tighten the boundary had a nationalist tendency too. Hungarian chemists wanted to prohibit the employment of immigrant chemists. They wanted to exclude all competitors from the territory of 'Hungarian chemists'.

The underlying reason for this debate was the scarcity of jobs for chemists. An article explained this motive by referring to the growing number of graduates, which reached 28 in 1907, in contrast with the earlier 2-3 persons per year. The author stated that Hungary did not need further chemists. Therefore, their training at the Technical University should be stopped.[12]

The main goal of the first national congress of Hungarian chemists was to discuss the job situation, the measures to be taken for defending the common interests of the chemists, and to promote the development of the field. Because of the unclear boundaries, Halmi, the organizer of the congress, decided to make a survey about the number of Hungarian chemists. While doing this, he wanted to register all people who could somehow be considered as a chemist. According to his not very precise estimation, 540 persons were employed as chemists. They worked in different fields (Table 1), mainly in civil service (Table 2) and industry (Table 3); there were many more chemists in civil service than in industry. Remarkably, pharmaceutical industry was not listed. Public education proved to be the largest employer.

Table 1

Chemists' employment in various sectors

Sectors	*Number of persons*
Civil service (state or city jobs)	277
Industry	225
Private practice	26
Unknown occupation	110
Working in foreign country	32
Total	**670**

Table 2

Employment in Civil Service

Employment	*Number of persons*
Teacher (high school, industrial school)	109
Experimental stations	75
College (Hoch Schule) adjunct, assistant	32
City quality control institutes, customs officer	9
Total	**215**

Table 3
Employment in Industry

Employment	*Number of persons*
Sugar industry	37
Iron industry	26
Sulfuric acid, hydrochloric acid, chemical fertilizer	25
Distillation, yeast	23
Textile, dye industry	13
Total	**124**

In his survey, Halmi did not differentiate between the levels of training or between the schools. He apparently wanted to produce the largest numbers to prove the social relevance of the debate on the chemists' situation. Therefore, at the end of his article, he remarked that besides the chemists he listed, there would be some colleagues working in unknown jobs and other people with related expertise in neighboring fields such as pharmacists, physicians and teachers. With them, he estimated that the 230 participants of the congress represented around thousand people related to chemical profession. At the time this number seemed large. Halmi, however, seemed to forget that the representatives of the related fields did not attend the congress, although many pharmacists regretted their absence after seeing the success of the meeting. According to an article written by a pharmacist, the pharmacists' organisation had not even replied to the chemists' invitation to the conference because pharmacists had not recognised the significance of chemistry in their field, even in the search for new medicines.[13]

The main decisions of the congress included the harmonisation of interests of the industrial capital, and the chemist's profession. They decided to adjust the training of chemical engineers to the specific requirements of industry in the way that new departments would be set up and industrial chemists would occasionally give classes.

Conclusion

The first national congress of the Hungarian chemists can be seen as a typical act of boundary work. Apart from the nationalist dimension, the main task of the congress was to represent a field, as an entity in its own right. This policy context inspired the organisers to show chemistry as a large, powerful territory. They realized this aim by including into their census all possible groups that were related with chemistry, even the pharmacists. This act had nothing to do with any essentialist definition of chemistry. The organisers did not attempt to deduce the boundaries of chemistry from any metaphysical idea. In establishing the boundaries of chemistry, they were influenced, as explained earlier, by the interests of acquiring better job opportunities for people whom they considered chemists. In the discussions, it became clear that by chemists the majority of the speakers meant chemical engineers. They tried to exclude all graduates of industrial schools and the 'philosopher chemists', the graduates of Budapest University, from the field of chemistry.

Boundaries change according to the context. For example, Michael Polanyi, a philosopher physical chemist, sharply distinguished between pure and applied sciences, and opposed science policy in general. Based on his views, and many others, 'philosopher chemists' could be considered to be closer to chemistry than could the engineers, because 'philosopher chemists' had more theoretical orientation than had the engineers. Hence, in an essentialist approach they might seem to be more real chemists than were the engineers. Therefore, pharmacy is clearly outside the boundary of chemistry, at least until chemists wanted to occupy positions in pharmaceutical companies that became prevalent after the 1920s in Hungary.

Since then, collaboration (peaceful coexistence) has proved to be a normal form of relationship at the boundaries of chemistry, as the hafnium story exemplified. The chemist Hevesy collaborated with the physicist Bohr, inorganic and analytical chemistry with old quantum physics.

The exclusion and inclusion technique reveals that the boundaries are change according to context. Boundary work relies on various devices, including ideologies. Essentialist arguments, such as reductionism, the always-debated relationship between chemistry and physics, and biology can be considered such an ideological instrument in the never-ending negotiation about the boundaries of lands. In the policy approach, the relationship between chemistry and its neighbors is a changing, collaborative, and negotiable process.

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