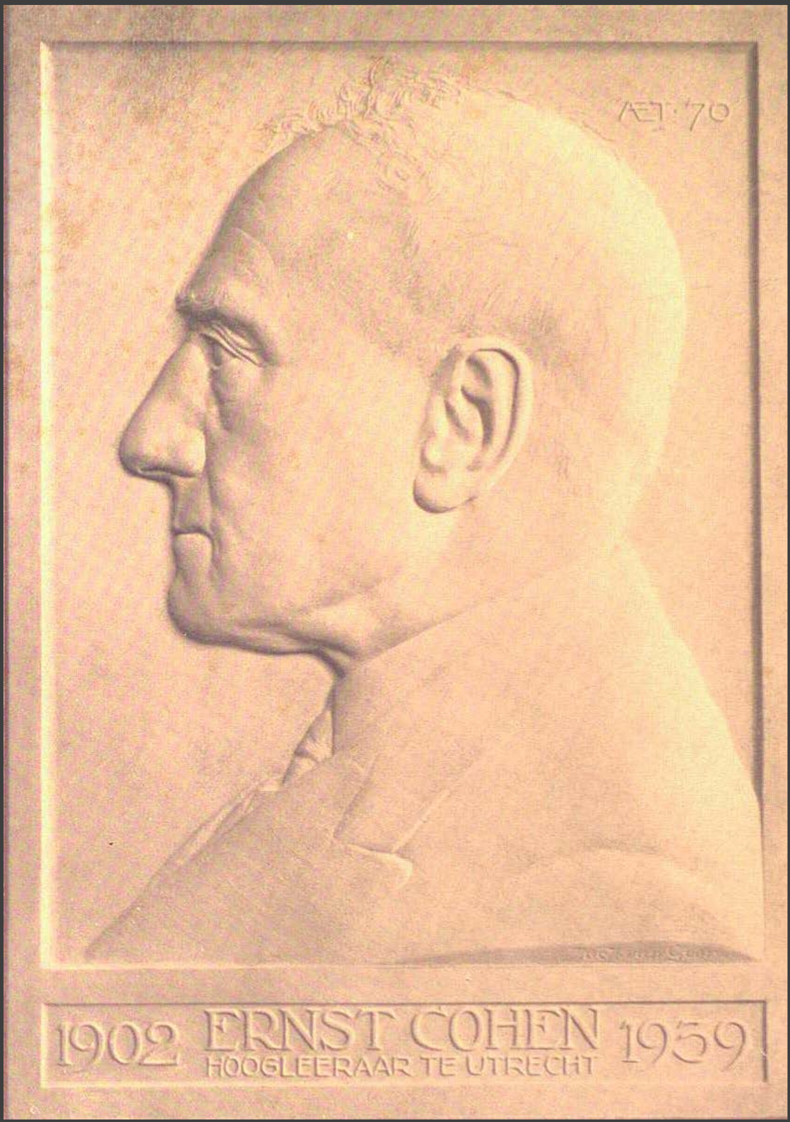
Purity in an Impure World

Ernst Cohen's 'General Chemistry' in early 20th century Netherlands



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Work, finish, publish.[1]

All in all, it's a matter of the interests of science and humanity.

These sacred interests, which side are they on?[2]

[1] Michael Faraday, quoted by J.H. van 't Hoff at Ernst Cohen's doctoral defense in 1893. Cohen (2013), p.52.

[2] 'A debate within a scientist's conscience' in Jules Romains' 1920 cinematographic tale '*Donogoo Tonka or The Miracles of Science*'. Romains (2009), p.23.

Contents

0. Introduction

In gold – "the metal that since centuries symbolizes purity" – the retiring professor Ernst Cohen received a replica of his own image.[3] In the speech at his 1939 retirement he discussed "50 years of revolution" in the field of physical chemistry. He preferred this scientific topic over a plea for "necessary reforms" in Dutch higher education and a defense of his opinion that "the adepts of natural science" should take a stance to "foil the chaos in which the cohabitation of nations is about to fall".[4] The 'pure' image, the speech and the unaddressed topics together capture the life of Ernst Cohen in science and society at the beginning of the twentieth century. Purity and the sense of revolution connect his scientific work to his societal engagement and situate physical chemistry, or what Cohen called 'general chemistry', in the culture of Europe and the Netherlands.[5] To understand the interrelations between science and society I followed the scientist as he moved around *outside* of his laboratory.

What could the pure science of general chemistry mean for Dutch society? With that question in mind I have explored the activity in the public sphere of Ernst Cohen. The public sphere starts where the laboratory ends. The engagement with any audience outside of the circle of direct academic peers is public. This includes audiences of other scientific disciplines, like physiology, audiences of chemists employed in 'practice', from secondary education to large-scale industries, and the broader audience of newspapers, courtrooms and cultural journals. The rhetoric employed in public activity is part of the societal legitimation of science: the process of acquiring support and recognition from the relevant social and political powers to secure

[3] Cohen (1939), p.22.
[4] Ibidem, p.1.
[5] These terms were often used synonymous, while 'general' was more common in Germany and 'physical' in English-speaking countries. The self-presentation of Cohen as 'general chemist' had epistemological implications, to which I turn below.

autonomy. The concept of "public science", introduced by Frank Turner, depicts the "body of rhetoric, argument and polemic" that is used in this process of societal legitimation.[6] With "boundary work" Thomas Gieryn described the societal process of allocating epistemic authority, i.e. "the legitimate power to define, describe and explain bounded domains of reality".[7] He diversified the concept of public science into a variety of representations of science relative to the different audiences, contexts and interests at stake. I have used the concept of boundary work as heuristic device in the analysis of the empirical material to discern the different rhetorical representations of general chemistry and natural science. The epistemic authority of science, and its demarcation from non-science, is established by a historically situated rhetorical 'clothing' of its product – knowledge, facts, artefacts. Both sociologically inspired concepts can however underemphasize this situation of science in historical culture. Therefore I interpret the public rhetoric and self-presentation of Ernst Cohen as he moved around in Dutch society, in line with Paul Forman, as a place where the co-production of science and culture becomes manifest.[8]

In the first chapter I locate a predominantly optimistic cultural atmosphere of the Netherlands in the context of a more ambivalent European modernity at the turn of the twentieth century. The concept of "purity" captures this ambivalence.[9] The newly risen science of physical chemistry fits into this picture with its air of progressiveness and sense of revolution. The experimental extension of the human senses inspired the self-conscious construction of a modern persona – and simultaneous co-creation of the 'classical'. This resonated with a desire in culture to break

[6] Turner (1980), p.589.
[7] Gieryn (1999), pp.1-5.
[8] Forman (1971), pp.58-60.
[9] Labrie (2001).

free from nineteenth-century tradition.[10] The First World War usually acts as the culmination point of the conflicting positive and negative elements of modernity. My historical study into Cohen's activity in the Dutch public sphere asks how he and his science fit in this culture of purity, progress and war-inflicted chaos. In the three chapters that follow I discuss, in consecutive time periods between 1900 and 1930, speeches, reports, actions and institutional reforms that situate science in society. Based on this empirical body of material I construct an understanding of the interrelations between general chemistry, Dutch society and modern European culture.

Through the historical narrative runs the conceptual thread of boundary work and societal legitimation. As public scientist Cohen related to education, to discuss the future of society, the world of engineering and technology, to associate science with industrial progress, and to civil society, to present science as essential element of culture. Outside of his laboratory he opposed himself to, was opposed by, and associated his science with, classicists, engineers, high school teachers, physiologists, politicians, religious leaders and many others. Related to these audiences, I identify three main representations of general chemistry: pedagogical, technological and cultural. Upon conclusion I reflect what properties, values and metaphors belonged to these different representations, and how this developed in the first decades of the twentieth century. As I follow Cohen through time, changes in Dutch society, the chemical community and the educational system come into play. This provides the background to evaluate how the First World War altered the relations between science and society in the neutral Netherlands. Ultimately, this will shed a new perspective on Cohen's role as mediator in the international

[10] Bigg (2008); Sibum (2008); Staley (2008), p.298.

chemical community after the war.[11] As a whole this thesis is an attempt to situate the public task of the university, or the societal value of science, in its historical culture.[12]

1. 1900 Purity & Progressiveness

"Purity is one of the most striking features of European culture around 1900".[13] Cultural historian Arnold Labrie used the concept of purity to connect a widespread sense of cultural pessimism, decay and degradation to a utopian belief in progress.[14] Purity is a "vague concept": in every historical period and cultural context it gains a different meaning. Purity is also a "boundary concept": purity produces impurity.[15] By definition, every formulation of purity excludes the impure, the dirty and the chaotic in an attempt to define the (social) order. The age-old desire for purity becomes particularly manifest in times of cultural crisis. At the end of the nineteenth century, the "modernization" of society hurled bourgeois Europe into an 'identity crisis'. "European bourgeois culture" was the shared way of thinking and living in which "order, family, possession, work, nation, cleanliness and self-control were the highest virtues".[16] "Modernization" denotes an amalgam of concurrent processes: industrialization, secularization, urbanization, democracy, bureaucratization, socialism, and feminism.[17] Many of the traditional cultural values came, consequentially, under pressure. As response a desire for purity emerged in nationalistic, hygienistic, and eugenetic movements. The European bourgeois "mentality and experience" became characterized by this desire for purity which, by its own logic, was

[11] This endeavor I have described in Smit (2014b).
[12] This connects to my internship at the Rathenau Insitute on "valorization", the current formulation of the university's public task. Smit (2014a); Jong et al. (2015).
[13] Labrie (2001), p.31.
[14] Henkes (2006), p.535.
[15] Labrie (2001), pp.23, 44.
[16] Ibidem, pp.21, 30.
[17] Baneke (2008), pp.22-28; Labrie (2001), p.30.

accompanied by a fear for decay and degeneration.[18] Labrie recognizes also in scientific spheres the urge for purity in the notion of 'pure science', especially in distinction to applied science.[19] 'Pure science', as self-description of scientists, became common in the nineteenth century to emphasize the cultural autonomy of science, its epistemological norm of objectivity and its neutrality with respect to political and moral issues.[20] It depends on the concrete cultural and historical circumstances in what way this desire manifested itself. In the Germany of Hermann von Helmholtz and Emil du Bois Reymond, for example, 'pure' natural science was the "cultural production" of natural scientists who aimed to discard their subordinate position in the medical faculty and instead wanted to associate themselves with the higher status of the traditional philosophical faculty.[21] Purity as ideal of science is the historical manifestation of the contested attempt to arrange the place of science in society and as such also relates to the cultural senses of decay and progress.[22]

1.1 Dutch Culture: Critical Optimism and National Confidence

A small nation in the North West of Europe – the Netherlands – did not share the European "nervousness and decadence". A sense of "critical optimism" dominated the Low Countries.[23] After a long period of stagnation and decay the Netherlands became an "established nation" in the last decades of the nineteenth century. Economic growth and industrial expansion went hand in hand with cultural-political emancipation and social mobility. The private exploitation of the Dutch East Indies, the coal and steel industry in the south-eastern provinces and a general

[18] Labrie (2001), p.31.
[19] Ibidem, p.23.
[20] Proctor (1991), p.3.
[21] Lenoir (1997), p.13.
[22] Proctor (1911), pp.262-263.
[23] Bank & Van Buuren (2000), p.13.

modernization of industry were the soil on which the Dutch culture could flourish.[24] A revived national self-awareness accompanied these changes and found its expression in the devotion of historical geniuses, like Rembrandt.[25] The cultural nationalism seems, at first sight, at odds with the increased fragmentation of Dutch society into communities organized along socio-political lines (*'verzuiling'* or pillarization). But just as the national self-confidence had to unite the people in times of great societal change, so did the various religious, social and political 'pillars'.[26] At the same time, increased secularization detached many from traditional moral frameworks. New individual norms and societal values were defined within their new social and professional communities.[27]

The modernization of Dutch society unfolded in educational reforms. The roots of the Dutch education system at the beginning of the twentieth century lay in two laws from 1865 and 1876 that standardized institutional powers and exam requirements.[28] An important reform had been the installment of a new type of secondary education, the *Hoogere Burgerschool* (HBS).[29] This school educated the youth for professions in trade and industry and prepared them to become worthy members of the modern middle class. The curriculum contained exams in the modern European languages and the natural sciences to prepare its students for these professional careers. This was opposite to the older and elitist *Gymnasium* which prepared for higher government and university positions through exams in the classics. The 1876 law introduced a national separation between the A and B gymnasium exam, the first with more attention for classical languages, the latter for natural sciences. Until 1917, it remained the only direct access

[24] Ibidem, pp.14-15.
[25] Ibidem, p.51.
[26] Sas (1991), pp.607-608.
[27] Bank & Van Buuren (2000), p.15.
[28] Wachelder (2000).
[29] Higher Civic School.

route to the university, while HBS students had to take an additional state exam in the classics. This nineteenth century system was designed as "end education" that prepared pupils for a certain social class. Towards the end of the century the emphasis shifted to "process education". Central became the individual's learning process ("pedagogization") and his vertical social mobility ("democratization").[30] Eventually, pillarization of society would also structure Dutch education, as from 1890 onwards different 'pillars' established "special" schools.[31] The changes in the Dutch education system reflected the change from a static, class-society of the first half of the nineteenth century towards a modern, democratic society that could compare itself to the rest of Western Europe by 1900.[32]

Between 1880 and 1914 both art and science benefited from and contributed to the progress and confidence of Dutch culture. The cultural elite shared in the new "national self-confidence" by relating itself explicitly to the Western European world. Foreign artists, on the other hand, sketched images of the Netherlands as a country not yet tainted by the "utilitarian industry" where a pure, "unspoiled country life" still existed.[33] Illustrative is the artist movement of the '*Tachtigers'*, the 'Generation of 80' that rose in the Netherlands in the 1880's. Confidently they presented themselves as breaking with the traditional literary establishment under slogans as "*l'art pour l'art*" and "the most individual expression of the most individual emotion".[34] This individualist generation was however, compared to predecessors and surrounding countries, less revolutionary than they presented themselves. Eventually, they did spark "upheaval" in the Dutch ideas about the relation between art and society. Many of them transformed into the

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[30] Wachelder (2000), pp.67, 80.
[31] Bank & Van Buuren (2000), p.250.
[32] Bank & Van Buuren (2000), pp.250, 265; Sas (1991), p.606.
[33] Bank & Van Buuren (2000), pp.18, 46-47.
[34] Colmjon (1963), pp.30, 34.

‘*Negentigers’*, the ‘Generation of 90’, that opposed the individualism to the ideal of community art.[35] This social ideal connected well to the “deep-rooted ethical impulse” and cultural optimism of Dutch society.[36] The ideals varied from somewhat vague, socialist and utopian to more retrospective, catholic and aristocratic. While the Generation of 80 fell apart following disagreement about the societal role of art, the Generation of 90 could only exist as long as a harmonious relation existed between the community ideal and the freedom of the artistic individual.[37] What both movements shared was a “new elitist citizenship ideal” through which the cultural elite distinguished themselves from the cultural masses by aiming for the highest esthetic and intellectual satisfaction, be it in name of the individual or the community.[38]

The sense of novelty and progress in the arts was reproduced in the sciences. The Dutch scientific culture around 1900 has been described, by contemporaries and historians, as the “Second Golden Age”, thereby referring to the glorious Dutch seventeenth century.[39] Obviously, this related directly to the optimism, revived nationalism and historical awareness in Dutch culture as a whole, and the new elitist ideal of citizenship manifest in the arts in particular. This self-confident sense of revolutionary progress is as important as the practical changes. The institutional explanation, introduced by Bastiaan Willink, focused on the latter and sees the origin of the scientific progress in two education laws. The 1865 law on secondary education established the HBS, which increased the amount of teacher positions in the sciences. The 1876 law on higher education increased the amount of professors, while the student intake decreased, so that there was relatively more time for research. In a culture of “bourgeois scientism”, adopted

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[35] Bank & Van Buuren (2000), p.151; Maas (2001), p.21.
[36] Krul (1991), pp.591-592
[37] Bank & Van Buuren (2000), pp.154, 192.
[38] Mijnhardt (2004), pp.24-25.
[39] Ibidem, pp.33-35.

from Germany, the government expenditures increased, of which the building of new laboratories was most impressive.[40] Many have argued however that the changes at the university should not be explained top-down, but rather have to be understood as one element of the general prosperity and democratizing culture in the Netherlands.[41] On the opposite side of the spectrum is the cultural explanation of Ad Maas, who locates the main cause of the progress in the individualistic geniuses that undertook groundbreaking scientific work in spite of institutional circumstances.[42] He relates this specifically to the individualism and "pioneer spirit" of the generation of 80.[43] Clearly, the Dutch scientific culture of self-confidence, optimism and nationalism fits in the historiographical image of the Netherlands around 1900. In this context the notion of "pure science" is one of many manifestations of the desire for purity in European culture and the progress in Dutch society. Under this header, the scientific community established its autonomy, cultural identity and national prestige. The association of the 'golden' generation of scientists with the Generation of 80 made Maas claim that science became detached from society. Others argued, in contrast, that science at the turn of the century was right in the middle of society. In Dutch natural science at the beginning of the twentieth century I observe the same tension as in the arts between individuality and community, captured in the sense and ideal of purity.[44]

The traditional historical image marks the end of the idealistic optimism in Dutch culture at the outbreak of the First World War in 1914.[45] It has also been mentioned that 1900, as much as

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[40] Willink (1988), pp.227-228, 244-246.
[41] Van Berkel (2004), pp.8-9; Maas (2001a), pp.15-17; Mijnhardt (2004), pp.34-36.
[42] Maas (2001a), pp.18-21; Maas (2001b).
[43] Maas (2001b), pp.373-374.
[44] Maas argues that the 'science pour la science' ideal detached research from society, while Theunissen on the other hand claims that pure science was directly related to practical use and therefore located in the middle of society. Maas (2001), p.21; Theunissen (1994), p.142.
[45] Baneke (2008), p.39.

it was the “heyday”, was the beginning of the downfall.[46] This connects to the characterization of Dutch culture that Baneke distilled from the public rhetoric of scientists between 1900 and 1940. More strongly than others, he identifies a fin de siècle in the Netherlands of cultural pessimism with respect to modernity. The search for “synthesis” that was the response of Dutch scientists to the modernizing society, carries the same double-headedness as the unifying concept of “purity”. It denoted both pessimism about fragmentation and hope for a harmonic future and, parallel to this, natural science was both the cause and the solution to these problems of modernity. Baneke further claims that not the war, but rather the economic crisis at the end of the 1920s was a breaking point for the rhetorical relation of scientists to society. Still, he agrees in part with historiography that the utopian ideals waned and were replaced by more “concrete and realistic initiatives”.[47] My focus in this thesis on one physical chemist is a way to assess the respect in which the First World War changed his words and actions as he moved around outside of his laboratory. This chronological biographical image of the public science of one physical chemist, cuts perpendicularly through the thematic study on the public role of scientists by Baneke. This connects to approaches in historiography of science that take biographical material as an opportunity to highlight the social-cultural embedding of science and the tension(s) between structure and agency.[48]

1.2 Physical Chemistry: Peripheral Progressiveness

To situate the story of Cohen’s chemistry in culture, I will describe the international and national scientific world that he grew up in and became a part of. As Cohen lived during the ‘identity crisis’ of European bourgeois culture, he experienced from close by the formation of

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[46] Jan Romein, quoted in Van Sas (1991), p.599.
[47] Baneke (2008), pp.44-45.
[48] Dorsman (2013), pp.11-13, 22-23.

physical chemistry as an autonomous disciplinary identity. Discipline is by its etymology two-headed: it depicts a field of knowledge (or art or sport) on the one hand, and a “social power-wielding activity” on the other.[49] The ‘identity’ concept of scientific discipline conflates both meanings of discipline to attend both product and process of science, grasping the sciences as culturally embedded social and practical activities with high cognitive content.[50] This ‘holistic approach’ is an explicit move away from an objectivist-realist approach that overemphasizes theory and characterizes science as disinterested pursuit of scientific knowledge. It attempts to make manifest how science is always already embedded in a cultural lifeworld and simultaneously produces its own version of social reality.[51] The disciplinary identity concept ties together a set of cognitive, technical, social and institutional elements. Laboratory techniques, research methods, codes of behavior, ideals of objectivity and truth, initiation processes, professional genealogies, physical space and independent channels of communication all contribute to the establishment of a disciplinary identity.[52] The factor of societal legitimation, the challenge to gain support and recognition from society, is a not too often mentioned factor. But, as Paul Forman has stressed, strategies of societal legitimation are strongly shaped by cultural surroundings and can ultimately also regulate what topics are researched and in what way results are achieved and presented.[53] To situate a discipline in society, I focus on the “self-presentation” of scientists that is formed under “social pressure”.[54] The cultural embedding of a science makes it worthwhile to investigate disciplinary identities in local communities.[55] The ‘general

[49] Goldstein (1984), p.178; Van Lunteren (2013), p.93.
[50] For this understanding of disciplines I rely foremost on the identity concept of Nye (1993), the ‘holistic’ approach of Wegener (2011) and the ‘cultural production’ of disciplines of Lenoir (1997).
[51] Lenoir (1997), pp. 4-8.
[52] Kuhn (1976); Lemaine et al. (1976); Van Lunteren (2013), pp.93, 100, 106; Tollebeek (2013), pp.84, 87.
[53] Forman (1971), pp.58-60.
[54] Wegener (2010), p.13.
[55] Nye (1993), pp.17-19; Wegener (2011), p.29; Lunteren (2013), p.110.

chemistry' of Cohen's Van 't Hoff laboratory will act as a local manifestation of the international disciplinary identity of physical chemistry. In this way I stage the societal involvement of the general chemists as element in the growth of their disciplinary identity which I situate in a culture permeated by a desire for purity.

It has become a historical cliché to locate the birth of physical chemistry at the 1887 foundation of the *Zeitschrift für Physikalische Chemie* by Arrhenius, Ostwald and Van 't Hoff. Several historians called this sudden appearance of physical chemistry in the 1880's and 1890's into question and pointed at journals, chairs and departments acting under this label earlier in the nineteenth century.[56] The foundation of a separate communication channel for the research field not only marked the moment when enough research was being executed to fill an autonomous journal but also a confident self-awareness. It is indicative of identity formation because chemistry was dominated by organic chemistry in the nineteenth century. It was precisely the existence of this peripheral region in the scientific community that facilitated the opportunity for Ostwald to establish a school based on the theoretical ideas of Van 't Hoff and Arrhenius.[57]

Aside scientific periphery, the confident self-perception of innovation and progress was characteristic for physical chemistry. It grounded in "a self-conscious effort on the part of the more enlightened, physicalist chemists to rejuvenate" chemistry, by presenting traditional chemistry as a "nonphysical, nonmathematical, somewhat premodern" science.[58] Physical chemists presented themselves in distinction as fundamental, mathematical, physical and modern.[59] More than a complete break with this tradition of experimentation and inductive

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[56] Nye (1993), pp.105-106.
[57] Dolby (1976b); Nye (1993) p.107; Servos (1996).
[58] Barkan (1999), p.9; Servos (1996), p.63.
[59] Servos (1996), pp.90-91.

reasoning, they shifted the priority to theory, mathematics and deductive reasoning.[60] This was accompanied by a desire to unite chemistry and physics, challenging traditional disciplinary boundaries.[61] Many definitions were given for physical chemistry towards the closing of the nineteenth century corresponding to the plurality of methods, approaches and practices. This plurality was united by a common 'progressive' research agenda. The self-presentation of the physical chemists in terms of "progressiveness" was a way to draw students, funding and institutional support to the new field.[62]

The awarding of Nobel Prizes in chemistry to the three '*Ionists*' – Van 't Hoff, Ostwald and Arrhenius – in the first decade of the new century symbolically established "the legitimacy and success of the new field" as impressive combination of fundamental science and industrial progress.[63] The case for usefulness was another element of the 'progressiveness' and was made "with uncommon vigor" by many physical chemists. Partly, this found its ground in the expanding commercial implications of the investigations in physical chemistry in the last decades of the nineteenth century.[64] They drafted this confidence from their scientific emphasis on generality: they studied the general principles of chemical reactions, instead of focusing on the behavior of particular substances. This initiated the idea that many unsolved problems from industry and other scientific disciplines like physiology and geology could be put in a whole new light by physical chemistry.[65] However, a great discrepancy existed between the rhetoric of the self-presentation and intellectual hagiography of the discipline and the achievements in

[60] Servos (1996), pp.40-41.
[61] Barkan (1999), pp.14-15; Nye (1991), pp.110, 138; Servos (1996), pp.41-42.
[62] Barkan (1999), pp.14-15.
[63] Nye (1991), p.108.
[64] Nye (1993), p.108.
[65] Servos (1996), pp.4, 66-69.

practice.[66] Servos claimed that the discipline satisfied many "intellectual" but only few "societal" needs around 1900.

In this thesis the progressiveness of physical chemistry – both the scientific appeal of novelty and the societal promise of utility – is understood as part of the identity that the new science constructed in distinction to other scientific fields and cultural spheres. In the identity of physical chemistry the purity of fundamental research was combined self-evidently with progress in society. This makes the discipline an interesting focal point because it resonates clearly with the European and Dutch culture around 1900. And, by 1920, the relations between this science and society had changed radically. In the United States, for example, the war "catalyzed" long-running developments in the structure of American industry and altered the values of businessmen and scientists.[67] Even more so, this was the case for the European nations directly involved in the war. These nations mobilized many scientists for their expertise and installed new departments, institutions and organizations that had to secure the use of science for society.

1.3 Physical Chemistry: A Dutch disciplinary identity

From the speeches Ernst Cohen uttered at the beginning stages of his professional academic career we can get a good grasp of his perspective on physical chemistry at the turn of the century. The boundary work, performed by Cohen *within* the world of science allows the identification of a local, Dutch identity, represented by Cohen's Van 't Hoff laboratory.[68] I will also introduce Charles van Deventer, a physical chemist, high school teacher and literator, who shared Cohen's scientific background in Amsterdam and would work with him in Utrecht. He is

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[66] Barkan (1999), pp.11-13; Servos (1996), p.203.
[67] Servos (1996), pp.203, 211-213, 220.
[68] Gieryn suggests this use of boundary work to map the "ideological demarcation of disciplines, specialties or theoretical orientations *within* science". Gieryn (1983), p.792.

especially interesting as point of comparison because, as a boundary figure between science, classics and literature, he related in a different way to the cultural audience of the Netherlands.

Cohen had an obsessive concern with the name of his field, which connects him to the central role of language in the concepts of “purity” and boundary work: language defines one’s identity by excluding the other.[69] In his inauguration speech for his position as extraordinary professor at the University of Amsterdam, Cohen discarded the Dutch ‘*scheikunde’* (art of separations) in favor of the more international and more general ‘*chemie*’ (chemistry).[70] The latter term dated back, according to Cohen, to the ancient ‘*chemia’*, ‘the science of Egypt’. This historical contingent name left him plenty of conceptual space to move around in, which he subsequently used to disjoint his new field from a persevering image of chemistry as art and craft. When Kant, at the end of the eighteenth century, set chemistry aside as a ‘*systematische Kunst oder Experimentallehre’* he determined the scientific image for chemistry for a century to come.[71] Cohen rebutted the “ignorabimus” of the famous philosopher: physical chemistry satisfied Kant’s criteria for a true science because the “mathesis” played an important role in chemistry’s “principles and methods”.[72] In this rhetorical move, he not only presented physical chemistry as a ‘real’ science in distinction to a premodern art, he also reproached the authority of philosophers to formulate predictions about the future of science.

More than a name, a field also required a definition of its scope. But previously, argued Cohen, chemistry threw a “mysterious veil” over itself by lengthy descriptions and complicated nomenclature to separate its practice “artificially” from physics.[73] The new physical chemistry

[69] Labrie (2001), pp.17-18.
[70] Cohen (1901b), p.8.
[71] ‘Systematic art or experimental doctrine’. Kant (1900), p.471.
[72] Ibidem, pp.13-15.
[73] Ibidem, p.7.

instead aimed at a "peaceful" union of physical and chemical knowledge, techniques and skills. Cohen specified physical chemistry further, because it had to be clear it was not just another "branch" on the tree of chemistry, an ontological region defined by a type of substance like organic chemistry. "Instead", said Cohen, "she comprises our entire science; only some of her methods she adopts from physics, and her theories have to be or become those of all branches" of chemistry: "inorganic, organic, physiologic, medical, pharmaceutical, mineralogical, analytic and technical".[74] Such a majestic scope was accompanied by a simple name and a succinct definition: "*General* Chemistry … is the doctrine of substances, their properties and conversions'.[75]

In *De Nieuwe* Gids, the journal published by the Generation of 80, Van Deventer already very early on described the Dutch involvement in the new physical chemistry and its relation to physics.[76] Van Deventer studied chemistry in Amsterdam with Van 't Hoff and wrote a historical dissertation under the supervision of J.W. Gunning. Although he studied at the HBS, he developed a great love for and knowledge of Greek and antique philosophy. During his study in Amsterdam he was member of the literary association *Flanor* where he became well acquainted with the writers of the Generation of 80. He was a boundary figure, difficult to locate in one sphere, but rather well-versed in art, humanities and science. Often, he was able to combine these various interests. Between 1885 and 1887 he managed to do this by informing the progressive literary audience of the latest physical chemical progress. He presented these developments in chemistry explicitly in relation to physics: chemistry "extended his hand [to physics]", but "physics only agreed halfway, that chemistry wanted to make its toilet and converse in

[74] Cohen (1901b), p.12.
[75] Ibidem, p.13.
[76] Van Deventer (1885a; 1885b; 1887a; 1887b)

respectable company about issues that transcended its education".[77] The physical chemists that incorporated mathematical reflections in their work did not only have to fight ground with physicists who perceived it as "fiddling about", but also with chemical colleagues who regarded mathematics a "sluggish steel corset for the free forms of chemistry".[78] As such he presented physical chemistry as a progressive movement breaking with the straitjacket of the past, similar to the self-perception of the Generation of 80. But he also set science apart from art. In a review of a physics learning book he condemned the author for presenting atomism with a "tone" of "empirical science what really *is* hypothesis". Van Deventer motivated this reprimand of "tone" by distinguishing natural science from the literary movement he was himself closely associated to: "tone works powerfully in our impressionistic time".[79]

Cohen and Van Deventer both became proficient in physical chemistry at the University of Amsterdam under the guidance of the internationally prominent Jacobus Henricus van 't Hoff. Cohen became also closely associated with his successor, Hendrik Willem Bakhuis Roozeboom. From both chemists he learned to appropriate thermodynamic principles to chemical processes, reactions and equilibria. This directed attention from the peculiarities of different substances to the quantitative reaction features, like concentration, pressure and temperature, of the "chemical system".[80] Van 't Hoff's *Etudes de Dynamique Chimique* of 1884 described homogenic equilibria in ideal solutions, uni-, bi- and multimolecular reactions and affinity in thermodynamic terms. Complemented by the electronic dissociation theory of Arrhenius this enabled the qualitative and quantitative prediction and explanation of solution characteristics and course of

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[77] Van Deventer (1885a), pp.108, 110, 111.
[78] Ibidem, p.111.
[79] Van Deventer (1885b), p.504.
[80] Somsen characterized this as a transition of focus from "individuals" (particular substances) to "social relations" (the chemical system). Somsen (1998a), p.15.

reactions.[81] Bakhuis Roozeboom used the ‘phase rule’ to systematically describe, in thermodynamic terms, equilibriums between different phases (heterogeneous equilibria) in actual empirical situations. The ultimate goal of this deeply religious scientist was to classify all chemical systems according to this rule, which would reveal a “hidden order” in nature.[82] Van ‘t Hoff made Amsterdam into an international center of chemistry, where Cohen became acquainted with the entire international chemical world. The large attention in the Netherlands for the research in line of Van ‘t Hoff and Bakhuis Roozeboom was internationally unique, establishing something of a national and quite “esoteric” research culture, or disciplinary identity.[83] Between 1900 and 1920 almost all of the professors in physical chemistry at the Dutch universities were educated by this ‘Amsterdam school’.[84]

Cohen was considered one of the most talented students of Van ‘t Hoff and would ultimately become the “primus inter pares” of physical chemistry in the Netherlands.[85] The tradition of education and research that he initiated in the Utrecht Van ‘t Hoff Laboratory was a rather unique combination of the approaches of both founders of the Dutch physical chemical identity. Cohen studied both homogenic and heterogenic equilibria and his scientific work centered around two themes: purity and experimental extremes. Much of his research is the experimental and overly precise elaboration of the more abstract theoretical ideas of his teachers. The ‘piezochemistry’ of Cohen investigated, for example, chemical dynamics under extreme pressures. He named his research program a “chemistry of extremes” that had to break with the

[81] Barkan (1999), pp.10-11; Snelders (1986), pp.14-16; Somsen (1998a), p.14.
[82] Bakhuis Roozeboom used an architectural metaphor of a “building” with “rooms” to represent his aspired systematic research program. Somsen (1998a), p.16.
[83] Ibidem, pp.12-13.
[84] For example, in Leiden, Amsterdam, Utrecht and at the polytechnic in Delft students (or former colleagues) of Van ‘t Hoff and Bakhuis Roozeboom represented physical chemistry. Snelders (1997), pp.207-223.
[85] Hoytink (1979).

"narrow-mindedness" of human sensory experience.[86] He became most well-known for his systematic investigations into the allotropies of matter, in cooperation with many of his doctoral students. Allotropy is currently known as the property of chemical elements to have various structural modifications in the same physical state. At the time, the main contribution of Cohen was the experimental insight that the phenomenon of allotropy was not the exception, but rather the rule, what he called the 'metastability' of matter. Cohen was especially concerned about the influence the metastable forms of matter had on the determination of physical and chemical constants. The measurement of such values were performed under the assumption of chemical and physical purity, while the metastability of matter learned that most substances are physically 'impure'. According to Snelders, Cohen was an early adopter and advocate of the difference between chemical and physical purity.[87] Cohen's presentation of his science is permeated by the revolutionary sentiments characteristic to international physical chemistry and the cultural theme of purity. The latter was not only leading in his self-description as pure scientist but also a central topic in his scientific research. A remarkable resonance emerges on two levels between Cohen the general chemist – a pure scientist obsessed with purity – and the cultural desire for purity in a modernizing world.

Ernst Cohen was born into a cautiously modernizing Amsterdam in 1869 as the Dutch son of a German chemical industrialist and a Jewish mother of the wealthy Rosenthal family. While she introduced him to art and literature, his father shared the bourgeois virtues of useful citizenship and practical entrepreneurship. In an aristocratic and international environment of the Amsterdam elite and many German house guests Cohen experienced HBS education. He finished the state exam in the classics to study chemistry at the municipal university. There, he

[86] Cohen (1902); Cohen (1904), pp.24-25.
[87] Snelders (1997), pp.60-67.

completed his dissertation under Van ‘t Hoff *cum laude* in 1893 on a new electrical method for the determination of transition points. He had extracted this topic from Van ‘t Hoff’s *Etudes de Dynamique Chimique*, a book that remained central in his entire scientific career.[88] At his graduation, Cohen perceived three options for himself: become a *“Privat-Gelehrter”*, move into industry, or dedicate himself to pure science.[89] He briefly considered the first option, but Van ‘t Hoff advised against such isolation from the international world of science. The decision between industry and academic science was more difficult. He received several offers from industrial companies and it would have been a relatively evident choice considering the chemical industrialists in his family.[90] But, ultimately, he deemed this “professional circle” unsatisfactory. At the intersection of the European fin de siècle culture and the Dutch sense of cultural optimism, Cohen decided to follow the path shown to him by his master and to “remain active purely scientifically”.[91]

2. 1893-1907 Concrete Requests & Pure Presuppositions

Both Dutch culture and chemistry experienced progress and an increasing sense of confidence around 1900. The idea that physical chemistry could offer meaningful perspectives and useful contributions beyond its laboratory did not only exist in the scientist’s self-presentation. In the early years after his doctorate, Cohen was easily found by engineers, medical practitioners and high school teachers to introduce them to the ideas of physical chemistry. Through contract research, lecture series and holiday courses Cohen responded to these requests.

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[88] The full title read “The determination of transition points by electrical method and the electro motoric force in chemical conversion”. Cohen (2013), p.52.
[89] An independent scholar. Ibidem, p.63.
[90] His grandfather was the director of a vinegar factory, in Germany, and his father managed chemical factories in Brussels and Amsterdam. Ibidem, pp.16-17.
[91] “Zuiver wetenschappelijk werkzaam blijven”. Ibidem, p.63.

Below I discuss how he (re)presented his general chemistry to actualize the promise of transdisciplinary relevance and practical applicability to the different audiences. As Cohen obtained a permanent position as university professor, the concrete requests waned and instead he increasingly imposed the academic perspective on education and industry. His pure presuppositions became slowly more manifest in a professionalizing Dutch chemical community.

2.1 Requests for the 'fruits' of pure science

From 1893 onwards, Cohen was assistant at Van 't Hoff's laboratory in Amsterdam. He was the successor of Charles van Deventer who left for a position as gymnasium teacher in the Dutch East Indies. Cohen provided laboratory training to medical students and, later, supervision to chemistry candidates that were preparing their dissertation. With the departure of Van 't Hoff to Berlin, in 1896, and the assignment of Bakhuis-Roozeboom a "new era" started. Cohen now took care of the lectures in physical chemistry – except for the phase rule – and obtained the status of "*privaat docent*", an unsalaried lecturer.[92] It is in these years that besides scientific education, he became active in research. Between 1897 and 1899 he started his investigations into the electrochemistry of standard elements and into the "peculiar behavior of metallic tin at low temperatures" which would lead to his lifelong research program of the metastability of matter.[93] At this point in his life, as the new century was dawning, Cohen and his chemistry were approachable and accessible to practitioners from medical, educational and technical spheres.

2.1.1 Physiology and medicine

The relevance of physical chemistry for the study of life by biologists, physiologists and medical practitioners, knew a certain self-evidence at the end of the nineteenth century. Physical chemists and physiologists alike stressed in public lectures the "physiological importance of

[92] Cohen (2013), pp.53-54.
[93] Ibidem, pp.68-69.

physical chemistry", "the application of physical chemistry in medicine" or "the importance of physical chemistry for the medical sciences".[94] But this rhetoric of a few protagonists that tied together the two sciences did not directly trickle down to the general practice of these fields. Initially, the interest of Dutch physiologists was passive and only small practical consequences could be reported.[95] In this context, I study the publication of two apparent successful textbooks by Van Deventer, in 1893, and by Cohen, in 1901, on physical chemistry for a medical audience. The way in which physical chemistry was accommodated to its specialized audience demonstrates how the discipline was established and perceived outside of its own academic circle.

Charles Marius van Deventer was assistant to Van 't Hoff in Amsterdam when he wrote an introduction into physical chemistry "for beginners".[96] This systematic textbook served, at first, the purpose of educating an audience of medical students who were preparing for the medical exam. The textbook was quite successful as several editions appeared in Dutch, German and English.[97] As Van Deventer left for the Dutch East Indies, Cohen edited the three German editions and added a chapter on electrochemistry.[98] It became a general textbook of physical chemistry for physicians, medical students, pharmacists and beginning chemists. In the foreword to the German edition Van 't Hoff presented Van Deventer's book as the missing handbook to the underlying chemical principles of physical chemistry.[99] With the authority of his Berlin chair he emphasized his close relationship to the author who had "heard my lectures, worked with me in the laboratory". The foreword ended with a rhetorical exposition of the "fruitful field" of

[94] Respectively Hoff, J.H. van 't (1891) at the NNGC, Cohen (1899) at the *Provinciaal Utrechts Genootschap voor Kunsten en Wetenschappen*, and Hamburger, H.J. (1901) in his inauguration speech.
[95] Snelders (1993a), p.22; Servos (1990), pp.68-69.
[96] Van Deventer (1893).
[97] Van Deventer (1897; 1899; 1901; 1906).
[98] Cohen (2013), p.75.
[99] Van Deventer (1897).

physical chemistry that generated fundamental reforms "from geology to physiology". Van 't Hoff legitimized the author through authority, and the scientific field by its transdisciplinary significance.

In the case of Cohen, it was the audience that actually first approached him. Two medical scientists had requested a lecture series on the "accomplishments of the General Chemistry".[100] "Con amore", with love, he had responded to the request of the medical audience by delivering nineteen Saturday mornings long a course on "physical chemistry for medical practitioners".[101] The lectures in Amsterdam were attended by several professors, physicians, medical assistants and a medical officer from the military.[102] The *Nederlandsch Tijdschrift voor Geneeskunde* published the texts of the lectures weekly between January 7th and March 11th,1901.[103] This greatly increased the range of distribution of the lectures, from about twenty live attendants to the complete professional circle of physicians in the Netherlands. Cohen published the lectures in book form and also prepared a German edition as he realized that the book could have use to even wider circles.[104] "Upon instigation" of the mechanical physiologist Loeb an "American translation" appeared that spread Cohen's physical chemistry also in the 'New World'.[105]

Cohen recalled, in his autobiography, that it was no coincidence these requests emerged at that particular moment. He claimed that the medical sciences became aware of the high potential of physical chemistry through the "pioneering work" by Hugo de Vries, in biology, and by Hartog Jakob Hamburger and Jacques Loeb in physiology.[106] In the foreword to the published

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[100] Cohen (1939).This were Dr.med. E.C. van Leersum and Dr.med. J.M. Baart de la Faille who would both later become professor, as Cohen was eager to note in his autobiography. Cohen (2013), pp.72-73.
[101] Cohen (1901c).
[102] For the complete list of participants see Snelders (1993a), p.34.
[103] Dutch Journal for Medicine.
[104] Cohen (2013), p.73.
[105] Cohen (1901d); Cohen (1903); Cohen (2013), p.73.
[106] Cohen (2013), pp.72-73.

edition of his lectures Cohen proclaimed that physicians needed “knowledge of the [physical chemical] theories and methods” because more and more use was made of these in medical scientific literature. His aim with the lectures was to open “the Book with the Seven Seals” and show the “intimate relation between the youngest branch of chemistry and the biological sciences”.[107] Besides this predominantly theoretical dimension, the audience had specifically asked for concrete expositions of the “most important methods”. The vantage point of the lectures was the pure physical chemistry of his teacher Van ‘t Hoff. The structure of the lecture series mirrored the lay-out of the *Études de Dynamique Chimique* to a proportional extent.[108] Just like the first three main parts of Van ‘t Hoff’s foundational work, Cohen discussed subsequently reaction speed (lecture 1), influence of temperature on reaction speed (lecture 4) and the equilibrium (lectures 5, 6, 7, 8). From a chemical point of view he omitted the subject of affinity and added the subjects catalysis and electrolytic dissociation theory that were formulated after 1884. From a medical point of view, he especially elaborated on fermentation, enzymatic activity, osmotic pressure in physiological processes and in general on “applications”. Thus, Cohen attempted to interweave physical chemistry with “the problems of the experimentally orientated medical practitioner”. In the lectures he not only introduced concepts and laws but also included mathematical formulas, tables and graphical representations of empirical data, and many detailed drawings of experimental instruments. In this respect, he differs from Van Deventer’s introductory textbook. Van Deventer had, for his medical audience, excluded any mathematical formulation and explained, exclusively by texts and examples the physical chemical principles and methods. According to Snelders, Cohen also still met the capacities and needs of his audience by making little appeal on thermodynamic principles and technical

[107] Cohen (1901c).
[108] Van ‘t Hoff (1884); Snelders (1993a).

knowledge.[109] Van Deventer's book was no manual for practice, but an introduction into the world and way of thinking of physical chemistry. Cohen's collection was clearly directed more at practitioners than at students, but it is questionable how accessible the abundance of data and mathematical formulations were to the medical audience.

Cohen obtained problems and applications appropriate for his audience from available literature in physiology and biology. This distinguished his lectures from a general textbook, as he accommodated the physical chemical principles to the kind of questions, problems and methods of his audience. For example, he illustrated the relation between temperature and reaction speed by work on the growth of plants, bacteria and eggs. Three lectures long Cohen discussed "applications", in which he took most effort to demonstrate the use of physical chemical methods and concepts for understanding organic processes. The sequence of lectures mirrored Cohen's epistemological perspective of a hierarchical relation between his general chemistry and the life sciences: the principles and methods of pure chemistry had to deductively enlighten the "obscure problems" of life.

The most elaborate examples of 'application' were the pharmacodynamic and hygienic problems of toxicity and disinfection. Laborious calculations and methodical expositions showed that knowledge on the activity and effectiveness of various solutions and substances could be gained with physical chemistry. These topics are clear hygienic and medical manifestations of the cultural desire for purity. It is remarkable that it is precisely to these research subjects of cleanliness, decay and disease that Cohen applies his general chemistry. This connects the purity of his science to the desire for purity in culture. Overall however, the exposition of the 'pure' chemistry was prevalent and clear-cut practical application in the medical organic world

[109] Snelders (1993a) p.24.

remained wanting. This lack of concrete examples put Cohen's epistemological perspective under pressure. To uphold the image that application to organic processes and progress in the life science followed linearly and top-down from pure chemistry he turned to a rhetorical representation of general chemistry. Application to the life sciences opened up a "wide field of research" which promised "a rich harvest" and would result in "rich fruits".[110] Van 't Hoff used similar rhetorical representations when he legitimized physical chemistry by sketching its potential service to other sciences.[111] This organic image of general chemistry and its future promise of transdisciplinary relevance implicitly reproduced the idea of a linear relationship between pure and applied science. In this representation the 'applied' life sciences became dependent on 'pure chemistry . Later, Cohen would explicitly use the image of the tree of pure science that grows the fruits of applied science, introduced by John Tyndall, to legitimize in a similar fashion his pure science to an engineering audience.

Cohen's and Van Deventer's textbooks disseminated physical chemical knowledge to an audience outside of their traditional scientific peer group. By the turn of the century the Dutch medical community requested an introduction to this approach as they expected direct use from it for their daily practices. The response of the physical chemists existed above all out of the reproduction of Van 't Hoff's research program and a hierarchical representation of the relation between their pure science and the 'applied' life sciences. In this context, the textbook becomes a creative and dynamic element of a scientific discipline that carries legitimating power.[112] Both Van Deventer and Cohen struggled with the impenetrability of mathematic formulas for their

[110] Cohen (1901d), p.240.
[111] Van 't Hoff (1903).
[112] This connects to currents in history of science that re-evaluate the textbook as a dynamic, progressive element of the cognate and social dimensions of science and discard the historiographical image, introduced by Kuhn, of textbooks as emblems of closed-off, 'normal' science. Kaiser (2005); Lundgren & Bensaude-Vincent (2000).

audience. The chemical world might have been quantified in mathematical relations, the organic world wasn't yet. They explained the physical chemical understanding of the organic world as much as possible therefore in qualitative terms. In both textbooks there is an overall emphasis on method, which combined the mathematical approach with a focus on systems instead of substances. The medical audience explicitly requested this physical-chemical perspective and in response received, more than practical results and ways of working, a new way of looking at the organic world.

2.1.2 National navy and commercial shipping

Cohen chose the path of pure science over industry, but engaged throughout his career with audiences of engineers and industrial chemists. I analyze how he related to these audiences in practice and how this corresponded to developments in the rhetorical representation of his academic chemistry. In the first decade of his university career Cohen appeared to be in tune with the needs and capacities of this audience. Cohen was well known in the practical world of electrical engineering as member of the *Nederlandsche Vereeniging voor Elektrotechniek*, and he became board member of the *Afdeeling voor Elektrotechniek* in 1900.[113] He published most of his work on electrochemistry in the scientific context of the proceedings of the Dutch Royal Academy of the Sciences and the *Zeitschrift für Elektrochemie*. Increasingly, his focus on the pure general chemistry would blind him for the experience, requests and sensibilities of practice.

Cohen was confident about the potential importance his scientific electrochemical research could have for a practical audience. The navy, several steam shipping companies, and shipping engineers acknowledged this also and actively requested the expertise of an "electro physicist"

[113] The Dutch Society for Electrotechnology. This merged into the *Koninklijk Instituut van Ingenieurs* (KIVI, Royal Institute of Engineers) in 1899 and became the *Afdeeling voor Elektrotechniek* (Department of Electrotechnology). Cohen (2013), p.73.

for a scientific explanation and solution of a practical problem. J.H. Beucker Andreae first established the urgency of the problem in a series of articles in *De Ingenieur*.[114] Beucker Andreae had previously served as colonel in the Dutch navy and as inspector of the *Rijks Stoomvaartdienst*.[115] The problem he introduced was the leakage, either caused by mechanical dislodging or corrosion, of copper condenser tubes in water tube boilers on board of steam ships. This could lead to the necessary temporary shutting down of one of the engines: a security risk for war ships and a much higher fuel use for commercial steam ships.[116] Especially the corrosion of the copper tubes, which occurred "as random as lightning", was a "complicated problem". Chemical analysis of corroded tubes had not provided any insight, and "practice" had only known "fruitless attempts" at undoing the "evil".[117] The probable cause was further obfuscated by simultaneous changes in steam shipping: the introduction of new boilers, the increase of electrical lighting, the changes in copper production and spreading use of steel in shipbuilding. Beucker Andreae concluded that "the true causes [of the corrosion] have to be traced in a logical manner" and the "remedies have to be indicated with certainty". To this end, he requested the financial support of his audience to enable "a competent, scientifically trained electro physicist" to perform "experiments on a large scale".[118] Based on his experience in both naval and commercials shipping spheres, he presented the problem of leaking condenser tubes in steam engines as an issue of national security and great commercial interest, also because the "good name" of the new water tube boiler and any ship using it, was at stake. Beucker Andreae

[114] Beucker Andreae (1900a-f).
[115] 'National Steamshippingservice'. Beucker Andreae (1900a), p.69; Cohen (1901a), p.178.
[116] Beucker Andreae (1900a), pp.70-72.
[117] Ibidem, p.73.
[118] Ibidem.

concluded that the savings in time, fuel and reparation costs were definitely worth the "costs of a thorough investigation".[119]

By August, 1900, half a year after his first report, he could proudly announce that the scientific investigations had already started thanks to the "generosity of some of our big steam shipping companies".[120] The 'competent electro physicist' was, of course, Ernst Cohen. In his elaborate report Cohen strengthened the importance of science by opposing it stronger to practice. The communications of practical experience, gathered by Beucker Andreae, were "accidental observations" that were not in agreement with each other. Because scientific "systematic investigation" was required, Cohen decided to ignore the practical reports completely.[121] Indeed in a very systematic fashion, Cohen subsequently presented the results of his experiments on the influence of sea-water on different materials used in condenser tubes. He moved from "chemically pure" copper to commercially available copper that was actually used in practice, and concluded that seawater attacked both pure and impure copper under the presence of air and carbon dioxide.[122] After he established the scientific conviction that the phenomenon existed, Cohen tested protection measures and possible other materials. His study was a systematic, experimental exploration of the phenomena, but did not provide a fundamental explanation. He concluded the study with results for practice and recommendations for protection measures.[123] Some were very pragmatic – thick layers of tin coating that corrode instead of the tube – others unexplained but useful – isolation from electric installations and running currents through the tubes – to actual solutions of which the technical feasibility was

[119] Ibidem, p.74.
[120] Beucker Andreae (1900e), p.583. Cohen explicitly named the different companies: Nederland" from Amsterdam, "Holland-Amerikalijn" from Rotterdam, "Koninklijke Paketvaartmaatschappij" from Amsterdam, "Rotterdamsche Lloyd" and "Zeeland" from Vlissingen. Cohen (1901a).
[121] Cohen (1901a), p.179.
[122] Ibidem, pp.179-183.
[123] Ibidem, pp.185-187.

unsure – non corroding coatings of copperoxyd or nickel. His investigations gained some name in the circles of naval and commercial shipping engineers, as he was invited to present his results at the English *Institution of Naval Architects.*[124] In the discussion that followed, English engineers from the navy and commerce both recognized the lack of an actual explanation and pointed at the high prices of some of the suggested materials. But overall they agreed that it was of "considerable advantage to our incomplete knowledge of the subject".[125]

Cohen rhetorically opposed the world of practice, of unwarranted induction and accidental observations, to an image of pure science as systematic, experimental and rigorous. But, similar to the interaction with the medical audience, Cohen's communication of general chemistry to the practical audience did not live up to the expectations which motivated the request of the engineers at first. Still, Cohen's experimental explorations of the corroding condenser tubes associated him closely to the world of practice. In 1902 *De Ingenieur* reported on his appointment as full professor in Utrecht and emphasized his membership of the Institute of Engineers and position on the board of the electro technology department. And although he moved "most freely on the general field of general chemistry", they explicitly mentioned his "important research" of technical chemical nature into the corrosion of condenser tubes on steam ships. The engineers counted him "already for long as one of us" and they expressed the hope that he would not "become completely unfaithful to technical chemistry".[126]

2.1.3 High school chemistry

By the end of the nineteenth century Dr. J. Campert, the director of the HBS in Amsterdam, introduced 'holiday courses' at the university aimed at high school teachers in the Netherlands,

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[124] Cohen (1902).
[125] *Transactions of the Royal Institution of Naval Architects*, 1902, 44, pp.220-228, esp.p.225.
[126] 'Uitersten op het gebied der algemeene chemie of physische chemie. De inaugureele rede van Prof.Dr. E. Cohen'. *De Ingenieur*, 1902, 17(1), pp.15-17, esp. p.17.

following German and French examples.[127] According to the high school chemistry teacher Dr. J.E. Enklaar this was typical for the Dutch "not very expansive and conservative" nature. New ideas like the holiday course were only imported after "careful deliberation" and prove of "practical feasibility" had been established elsewhere.[128] After the Dutch had seen "which way the cat jumps", their "thoroughness" did ensure proper implementation of the new ideas which they would then even grant "national character". Enklaar presented the introduction of holiday courses as a reflection of the cultural position of the Netherlands in Europe: still lagging behind, but trying actively, and proudly, to catch up. The novelty of physical chemistry, and the international excellence attached to the Amsterdam laboratory with the "great name of Van 't Hoff", connected well to this progressive desire.[129]

Bakhuis Roozeboom and Cohen responded positively to the request of Dr. Campert to organize a holiday course on physical chemistry, with a special emphasis on the methods, instruments and practical activity. During the Eastern holidays and at the end of August in 1899, Cohen took the responsibility for most of the course, as he oversaw the laboratory work and instruction. In both cases, the teachers experienced the practical introduction to the methods and instruments as extremely insightful, satisfying and exciting.[130] Besides the knowledge and experience obtained, they considered the established contact and interaction between the academic chemists and high school teachers even more important. The "exchange of thoughts" was "refreshing", so that the course expanded the teacher's "way of thinking".[131] To that extent, Cohen achieved his main aim to let the teachers "live in a purely scientific atmosphere" for a few

[127] Cohen (2013), p.70.
[128] Enklaar (1899a), p.193.
[129] Ibidem.
[130] Enklaar (1899b), p.246; Doyer van Cleeff (1899), pp.354-358.
[131] Doyer van Cleeff (1899), p.358.

days.[132] Enklaar fostered the hope that this would not remain an incident, and that it would mean the beginning of a closer connection between the laboratories at the university and the higher civic schools. The teachers in the “small, rural working places” would then continuously receive “advice, support and inspiration” from the urban academic centers.[133] Ultimately he predicted that this would be to the benefit of pure science: the amount of scientific workers, physical chemists in particular, would increase in the Netherlands.

Cohen optimistically partook in these ‘knowledge transfer’ activities at the turn of the twentieth century, to keep the knowledge of high school teachers up to date.[134] But, Cohen soon refrained from further concrete activities in this area. In his autobiography he remembers how there was “some use” for the participants, which had not to be overestimated because “only very few undertook independent research afterwards”.[135] Cohen was disappointed by the result of the interaction between the academic center and the chemical periphery of HBS teachers, which appeared to be based however on his own purely scientific criterion of new independent research. Below we will see how these ‘pure presuppositions’ shaped his later attempts at transferring university chemistry to the sphere of secondary education.

2.2 The pure presuppositions of the ‘temple of chemistry’

In 1902, Ernst Cohen was assigned full professor in Utrecht with the “life-task” of developing a “harmonious unity” between research and education.[136] The board of governors of Utrecht University planned a rejuvenation of its science faculty as the research in the last decades of the nineteenth century had not kept up with the ‘second golden age’. New professors

[132] Cohen (2013), p.70.
[133] Enklaar (1899b), p.246.
[134] Snelders (1997), pp. 60, 536.
[135] Cohen (2013), p.70.
[136] Cohen (1902a), pp.5, 10.

at state universities were formally appointed by the ‘Crown’, which in practice was the minister of Domestic Affairs, who most of the times followed the advice of the university’s board of governors.[137] From the 1876 law onwards, the voice of the faculty in appointments became also bigger and the circle of reference for new appointments widened from the local to the national, and sometimes international, professional circle. The board perceived Cohen as one of the most promising students of the creative and modern Amsterdam school, who would bring the latest developments in chemistry to Utrecht. Also Ernst Cohen himself perceived his appointment in Utrecht as a break with the past. His description of his predecessors expressed a self-understanding of a new beginning, a new century with new chemistry. He was well aware of his promising status as young and modern scientist and set high demands for his chair in “general and inorganic chemistry”. He dispelled the half century old “Leeuwenburgh” laboratory as “completely useless for my purposes”.[138] Cohen, carrying the new scientific self-confidence, set high demands for a new laboratory. Van ‘t Hoff even advised against this, as he was pessimistic about the appreciation of the Dutch government for science. Cohen’s self-confidence as scientific researcher is also reflected in his identification of “wounded parts” in Dutch education legislation that attended the research function of the laboratory: the lack of university positions for talented graduates, the absence of research positions and the abundance of temporary contracts for assistants.[139]

The board of university governors was especially concerned with his research task and they set Cohen up directly with the minister of internal affairs, and prime minister, Abraham Kuyper to discuss the possibilities. In an extremely autocratic way, Cohen obtained the resources to

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137 Faasse (2012), pp.67, 76.
138 Cohen (2013), p.78.
139 Cohen (1902a), pp.31-33.

construct his own laboratory for physical chemical education and research. This was the definite materialization of his decision to follow the path of pure science. It was also occasion for Cohen to contrast himself and his modern science with Dutch culture through the construction and presentation of his new laboratory. For the architectural design he received help from his friend Eduard Cuypers and for the building by the government architect Jacobus van Lokhorst. The artistic urges of both men to design neo-renaissance or neo-gothic styled buildings were contained by Cohen, who above all demanded an externally "simple" and internally functionalized and flexible laboratory.[140] The technical and scientific demands were leading in the design of the "temple of chemistry". According to Cohen himself, this was an effort to break with a Dutch tradition of too big labs with "excessive luxurious" exteriors.[141] His simple, small and thus extremely effective Van 't Hoff Laboratory was presented as break with nineteenth century decadence and instead represented the features of modesty and modern efficiency. In the following years Cohen would mingle in circles of education, industry and technology to impose the modern values of general chemistry upon the world around him.

2.2.1 Academic domination of the Dutch Chemical Society

Dutch chemistry professionalized at the end of the nineteenth century, simultaneous with Cohen's ascension in the academic world. The chemical community in the Netherlands formalized with the establishment of their independent society in 1903, of which Ernst Cohen became the first president. Cohen described the main goal of the Dutch Chemical Society in his opening word, which was published full length in the first edition of the *Chemisch Weekblad*: "the promotion of the interests of the practitioners of chemistry in the broadest sense of the

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[140] Cohen (1904b), p.12. Cohen (2013), pp.79-80.
[141] Cohen (2013), p.80.

word".[142] He took this last addition seriously and refused to further specify its "field of action" which would change, namely, with the "development of technology and science".[143] A university professor at the head of this new society was stranger than it may seem at first, and it would determine the academic domination of the Dutch Chemical Society for the decade to come.

The first initiatives for the society originated in the practically oriented *Tijdschrift voor Toegepaste Scheikunde en Hygiëne.*[144] This short-lived journal was the manifestation of a growing chemical community in the Netherlands at the end of the nineteenth century. The amount of high school teaching positions increased dramatically after the higher education law of 1876 which introduced the HBS. The job market for chemists also grew through the demand for trained chemists in the many public agricultural test stations that were installed at home and in the Dutch East Indies.[145] Also there was a rise of private laboratories that provided chemical analyses of food and other commodities. The chemists were trained not exclusively at the university. The 1876 law also instituted the polytechnic school in Delft. From the perspective of the university chemists, the societal position and job perspectives of academically trained chemists were threatened by these Delft technologists.

The chemical community in the Netherlands was in transition and the discussions about the scope of the new society and journal reflected this. University professors were skeptical at first, but finally agreed with the idea of a broad society "where industry and science could meet".[146] The inclusion of both academic and practical chemists – scientists, engineers and pharmacists – increased both the economic basis and readership of the society and journal. The larger share of

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[142] Cohen (1904a), p.1.
[143] Ibidem, p.2.
[144] Journal for Applied Chemistry and Hygiene. It existed from 1897 until 1904, when it was absorbed by the *Chemisch Weekblad.* In the letters to the editors sections the discussion about a society first emerged. Homburg (2008), pp.195-199.
[145] Homburg (2008), pp.195-196.
[146] Ibidem, pp.197-201.

the founding members (60%) held practical positions in chemistry. Homburg describes how the "intellectual and social gulf" between the academic chemists and the "middle rank trained" chemists characterized the society in the first ten years. Although the society formulated both science and professionally oriented aims in the statutes, especially the latter failed.[147] This gives a peculiar coloring to the fact that, until 1916, all presidents would be academic chemists. At the opening event of the society, the president Cohen of course presented the optimistic image that their society would play a role in the continuous interchange between "pure and applied science". He presented the society as a gathering of science, technology and industry and proclaimed the "opinion that theory and practice are opposed to each other" an "*uberwundener Standpunt*", a superseded standpoint. The interchange between science and practice was "needed and useful" and would benefit "national prosperity".[148] At this occasion Cohen did not distinguish pure science hierarchically from application and industry, but instead represented the relationship as intimate, useful and two-way. In this way he aimed to achieve unity in the newly founded society, attract as many members from all circles, and to present the academic leadership as self-evident.

2.2.2 The didactic value of deductive general chemistry

The organization of chemists in their own association was a way to secure their interests in society at large. In the first years of its existence the first president, Cohen, actively furthered these interests. On December 23rd, 1905, Cohen opened the third yearly meeting of the Dutch chemical society in Amsterdam with a speech on the chemical education in Dutch secondary education. A German report on natural scientific education was very optimistic about the "highly

[147] Ibidem, pp.206, 211.
[148] Cohen (1904a), p.6.

developed demonstrative education" at the Dutch HBS.[149] Cohen agreed that in this respect the Dutch education system was more advanced than in Germany, but dismissed the report's optimism. He even considered it an obstacle that no international precursor existed. Cohen evaluated the state of Dutch education much more pessimistic. He demanded fundamental reforms because the education of chemistry at the HBS did not correspond to the "present viewpoint of this science".[150] This reflects his conviction that the achievements of general chemistry had radically altered the content and methods of chemistry. He motivated the need for correspondence between the frontiers of, and the first steps in, chemistry in two ways. Of course, the educational methods at high school had to facilitate easy connection to university chemistry.[151] Besides this, Cohen considered it desirable that the pupils developed their "esthetic sense" with general chemistry, which presented a "clear image of the intimate coherence of natural phenomena".[152] Cohen presented general chemistry not as a normal branch of chemistry but as a synthetic activity that moved beyond a mere *kennen* and included *kunnen*.[153] He accustomed this topic to his progressive perception of chemistry and a pessimistic evaluation of Dutch society. To his opinion secondary education had not "made use" of the "new viewpoints" developed in the "era of revolutions" in pure and applied science.[154]

He drafted this conclusion from an analysis of available textbooks. Some had not at all taken into account the progress of the last twenty years, while most had failed to do this properly: general chemistry was described in supplements, instead of being the leading principle. Obviously, this evaluation of textbook approaches reflected Cohen's epistemological notion of

[149] Cohen (1905), p.805.
[150] Ibidem, p.807.
[151] Although HBS students could not enter university directly, a demand like this shows that many eventually did.
[152] Ibidem.
[153] Best translated as 'knowledge' and 'application' or 'skill'. He used this formulation in a second speech on the topic, see below, to mirror chemistry education to physics. Cohen (1906), p.533.
[154] Cohen (1905), pp.811-812.

the relation of general chemistry to the rest of chemistry. Opposed to the inductive chemistry of the nineteenth century, the "modern chemistry" was a deductive "exact science that aims to explain as many phenomena with as little premises".[155] He related his epistemological view to "didactic power". The old, "descriptive" chemistry only provided "factual knowledge" that put high demands on the "memory" of the student. The modern chemistry, on the other hand, provided "general principles" which activated the "mind" of the student. The practical experiments were there to test a "logically developed train of thought", which provided "pleasure" and developed the esthetic sense of the student.[156] Cohen here opposed the experiment in the modern sense, as the confirmation of a theoretically deduced claim, to the inductive activity of describing and classifying phenomena which he considered characteristic of 'unscientific' chemistry. He considered the approach of chemistry useful to all HBS students. Those that entered society directly or continued education in natural science or medicine had all developed their intellect, obtained knowledge of the current state of chemistry and, especially for the latter group, would save a lot of time with proper knowledge of chemical principles.[157] The deductive priority of theory over practice, and mind over memory, were occasion for Cohen to oppose education in modern science to the descriptive chemistry of the past and, sideways, also to the humanities. Cohen argued that the deductive reasoning, embodied by and required in modern chemistry, developed the esthetic sense and cognitive skills of the students in a way fit for the modern world which became increasingly dominated by science, technology and industry.

The high school chemistry teacher J.E. Enklaar protested against the professorial pessimism and the physical chemical pedagogy. Although he was a proponent of closer

[155] Ibidem, pp.812-813.
[156] Ibidem, pp.815-817.
[157] Ibidem, pp.817-818.

connections between the university and high schools, as we saw above, he disagreed fundamentally with Cohen's way of conduct. He questioned the factual evidence of Cohen's plea – the "living word" of the teacher did not simply equal the textbook – and in general his knowledge of practice.[158] Enklaar explained to Cohen that the HBS was not the same as a university, and that the relation between high school teacher and student differed substantially from that between professors and students. Cohen could claim that the HBS had to accommodate itself to the demands of the university, but what did the university do to accommodate itself to the HBS, asked Enklaar? [159] The overall claim of Enklaar was that Cohen wanted to push his own university and disciplinary interests upon the chemical education in secondary schools. In contrast, Enklaar perceived the new physical chemistry simply as another branch of the chemical knowledge tree and not as an overarching fundamental discipline. As a consequence he claimed that industrialists, organic chemists and physiologists were as much justified as Cohen to demand reforms that attended the principles and methods relevant to them. Rhetorically, he concluded that this would "tear the HBS apart".[160]

In the summer of 1906, Cohen came back to the issue upon the request of the *Vereeniging van Leraren van het Middelbaar Onderwijs*.[161] He took it as occasion to elaborate his argument and respond to the raised criticism. With a stress on his practical experience of "daily contact" with HBS graduates, he again emphasized the problem of the dominance of factual knowledge. This time he not so much attacked the pedagogical method of the textbooks, and thus implicitly the teachers, but characterized the root of the problem as administrative in

[158] Enklaar (1905), pp.22-23.
[159] Ibidem, pp.24-25.
[160] Ibidem, p.29.
[161] 'Association of High School Teachers'. Cohen delivered a speech at the general assembly that took place in Alkmaar in August 1906. Cohen (1906), p.529.

nature: the exam demands reflected the old definition of chemistry.[162] The Association of High School Teachers subsequently instituted a committee to address the controversy and invited both adversaries to participate. Cohen chaired the committee but Enklaar left it after the first meeting.[163] Euphemistically their conclusive report stated that at this meeting "4 out of 5 members realized quickly that agreement would not be difficult". Not surprisingly, the report of the committee followed the direction demanded by Cohen. Their reforms "simplify the entire education in chemistry". By giving more attention to the "general principles … as early as possible in the curriculum" pupils would be able to memorize facts more easily as well as to gain more insight in the coherence of phenomena. The report quoted Ostwald to present this reform in conjunction with the development of chemistry from "descriptive" to "rational" science. This demanded "higher think- and abstraction capacities" which improved the student's development and provided him with more pleasure from the deeper understanding.

The proposed reforms of the committee corresponded closely to the principles that were central to all of Cohen's research activities and originated in the structure of Van 't Hoff's *Études*. Reaction speed, equilibrium and ionization had to become central as early as possible in the chemical curriculum because their explanatory power "simplified" the learning process. The committee did however exclude the dynamic equilibrium and osmotic pressure from the high

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[162] Ibidem, pp.532, 534.

[163] Cohen et al (1906). The other members of the committee were both academically trained chemists and HBS teachers. S. Birnie was a chemistry teacher at a HBS in Rotterdam, who was well trained in the new physical chemistry. Snelders (1993), p.84. P.C. Kaz obtained his PhD degree in physics with Van der Waals. R.N. de Haas was a chemistry teacher at the HBS and in Wageningen at the "Rijkslandbouwschool" (State agricultural school), which was a non-universitary follow-up study after the 3-year HBS of similar standing as the polytechnic school in Delft. A. van Raalte was a HBS teacher who worked in Dordrecht at the "Rijkslandbouwwinterschool" (state agricultural winter school), which was part of the secondary agricultural education system at which many farmers followed practically-oriented education only in wintertime. After 1906, van Raalte became director of the "Keuringsdienst" (inspection department) in Amsterdam. Kooij (2009), pp.13-14.

school program. The inclusion of ionization in the HBS curriculum implied that atomism was the self-evident foundation of chemistry.

In the years 1905 and 1906, Cohen specifically addressed the circle of chemical professionals at the NCV and subsequently the HBS teachers in particular, to implement the principles of general chemistry as early as possible in the minds of the youth. Whether the recommendations of the report were followed is unknown, but that they also met criticism is evident. In historiography Enklaar is characterized from traditional and conservative to the embodiment of "widespread confusion".[164] This makes it all too easy to push aside the old Enklaar and present Cohen as the modern, progressive innovator. It would be a mistake, however, because it too simply follows Cohen's self-presentation. Also, Enklaar's optimistic involvement in the holiday course at Cohen's laboratory six years before indicates that he was definitely receptive for the new viewpoints of physical chemistry. The recommendation of the report to implement the structure and content of Cohen's general chemistry research program in Dutch secondary education then appears to be more a legitimating strategy than a necessary reform. General chemistry was modern, scientific, deductive and rational in distinction to the old, inductive, factual and descriptive chemistry of the previous century. Cohen extended this representation to advanced cognitive and esthetic capacities in an attempt to legitimize the introduction of his science in society, through the minds of the youth. The principles and methods of general chemistry developed the theoretical mind and esthetic sense so that the pupils could confront the fragmenting society. Lastly, Cohen explicitly attached the modern values of efficiency and utility to his reforms and science by stressing the resulting 'simplification'.

[164] Respectively Somsen (1998a), p.33; Baneke (2008), pp.130-131.

2.2.3 'Blind' universities in Dutch higher education

Perhaps the Dutch chemical society established in the first years of its existence more in the area of uniting academic chemistry, than uniting science and practice. This national academic unity was instead established in competition with the practical realm of chemical industry and technology. A sign of this is the 1904 address on "technologists and doctors in chemistry" that was a united effort of all Dutch university chemistry professors.[165] They opened with the remark that the importance of university chemistry education to "the chemical industry and the application of science" was "left out of consideration" in the 1876 law on the education of technologists.[166] In the address they presented three propositions to compensate this wrong. The address came at a moment when reforms in higher education were a point of national debate.[167] The most concrete proposed reform was the promotion of the polytechnic school to a *Hogeschool*, or college, by which it would obtain rights similar to those of the universities.[168] Aware of these plans, the university professors understood that the "ideal situation" of technology education at the university was not practically possible. With their cards on the table, the address became a rather desperate attempt to contain the future polytechnic college as much as possible, in defense of academic chemistry.

They presented a future in which the education at university and the polytechnic school were strongly connected. They proposed that university and technology students could switch schools

[165] The address, directed at the minister of Internal Affairs Abraham Kuyper, was signed by the professors Bakhuis Roozeboom and Lobry de Bruyn (both Amsterdam), Holleman (Groningen), Franchimont and Schreinemakers (both Leiden), and Romburgh and Cohen (both Utrecht). *De Ingenieur*, 1904, 19 (6), pp.123-124; Snelders (1997), pp.207-209.
[166] *De Ingenieur*, 1904, 19 (6), 123.
[167] In 1903, Minister Abraham Kuyper installed the *Ineenschakelingscommissie* ('connection committee') which investigated the entire Dutch education system. It took more than ten years before reforms were pushed, making it a recurrent topic of debate. Wachelder (2000), p.61.
[168] I use 'polytechnic college' as translation of *Technische hogeschool* to distinguish it from 'polytechnic school'. The status of the engineering school of Delft increased when it obtained *jus promovendi* in 1905 and even gymnasium students with a natural scientific program (B-students) were admitted. Baneke (2008), p.50.

after, respectively, their candidate and technology exam. This would enable "desired exchange" of students between the institutions, and allowed students to switch career paths later on. Their main goal was to draw technology (students) closer to the university. By sketching an image of the university research and education in "promotion of industry" they defended their interests. "The modern development of chemical industry…originated and still originates at the Universities", based on "frequently directly applicable discoveries" from the "laboratory of the man of science" and the "broad university training" of chemists who could "complete independent scientific work".[169] Undeniably, the seven professors were defending their own interests, as they proposed the denial of promotion rights at the polytechnic school and a limitation of the educational qualifications of graduated technologists. "Broader education and a scientific attitude" were required for teachers at the advanced high schools and this could only be obtained at the university.[170] This measure and motivation had to draw more technology students to the university and secure career perspectives in education for university graduates.

The editor of the *De Ingenieur*, R.A. van Sandick, did not let the address pass unnoted. Especially the chemistry professors' "peculiar position" that engineering education was best relocated to the universities affronted him.[171] Van Sandick sarcastically asked why the universities had remained silent on the issue for forty years, and how the reform into the *Technische Hogeschool* could make all those engineers suddenly unqualified for secondary education. He identified the academic "campaign" as an attempt to press their own agendas on the educational reforms. The university professors feared the situation in which the polytechnic college was the shortest way to a teacher's degree, while an engineer at the same time could

[169] *De Ingenieur*, 1904, 19 (6), p.123.
[170] Ibidem, p.124.
[171] *De Ingenieur*, 1904, 19 (6), pp.111-112.

much easier leave an occupation at a school for a job in industry. Although clearly an evil for the university, Van Sandick rhetorically wondered whether it would be so bad for "the youth", whose interests had to be central in the end. In his conclusive remark he presented the university as theoretical and detached from the practice of secondary education and culture in general: "Is the university so blind for the signs of the times, that she dares to deny that a boy of 12-18 would not learn as much from an engineer as from an exclusively theoretically, university trained graduate?"[172]

In the end, the reforms of 1904 would benefit the accessibility and career perspectives of the polytechnic school and the public appeal of the academic chemists had little impact. It is interesting to see that their representation of the relation between university science and industry took again the shape of a linear, hierarchical relationship. At the same time they also claimed that the broader development of the teacher could only be achieved at academic laboratories. This resulted in an image of the university in the middle of society, producing innovations in industry and educating practical chemists and high school teachers. Engineer Van Sandick opposed this rhetoric and instead characterized the university as theoretical and detached from society. In an attempt to secure student intake and career perspectives for their graduates, the university professors denied the raison d'être of the polytechnic school and constructed a monolithic but ambiguous image of their own institution.

2.2.4 Pure pessimism about Dutch chemical industry

Around the same time that the professors united to prevent a further rise of the engineering school in Delft, the board of the chemical society approached industry as well. The *Maatschappij voor Nijverheid* started an inquiry into the causes of the "minor development" of Dutch chemical

[172] Ibidem, p.112.

industry.[173] Under the leadership of Cohen the board of the still very young NCV offered to cooperate in this research. Explicitly Cohen made clear that this was not because they thought, “like Napoleon I”, that chemistry had to adopt to the needs of “war and industry”. At his inauguration in Utrecht, in 1902, Cohen had already declared that “large scale industry developed from theoretical chemistry” and that the laboratory experiments had their impact on the “economic situation of the entire civilized world”.[174] The way the chemical and industrial society joined hands is illustrative of the relation between the two spheres. They decided to investigate the situation independently and only discuss their respective results upon completion.

From the side of the chemical society four chemists were involved. Three physical chemists – Cohen, the Leiden professor Schreinemakers and lector Jorissen – and one organic chemist – Delft professor Hoogewerff. The eventual report carried the names of Cohen, Hoogewerff and dr. H. Yssel de Schepper, director of the stearin candle factory Gouda. The pessimistic vantage point of the investigation was reproduced in their final conclusions. They reported that the size of Dutch chemical industry was indeed small. The main cause of the low level of “industriousness” was the lack of natural resources and the accompanying low demand for technical personnel.[175] They believed that the obstructions to industrial progress were to be alleviated not by government intervention but by “personal initiative” in specific production circumstances.[176] To this end the education of the “technical leadership” had to include more practical experience in the curriculum. The state of the Dutch industry and technical education was in all dimensions considered inferior to the persevering image of the German close relationship between industry and university, in research and education. It was not just a lack of interest from Dutch industry

[173] The Society for Industry. Cohen (1904c).
[174] Cohen (1902a), p.16.
[175] Yssel de Schepper, Hoogewerff & Cohen (1904), pp.471-473.
[176] Ibidem, p.470.

for academic knowledge, because the German academics also had themselves "more interest in the problems of chemical industry". The chemical entrepreneur and the two professors explained the Dutch deprivation by the lack of an "intimate relation between education … and industry".[177]

It has been claimed by historians that the Dutch pessimism was partly unwarranted and informed by their definition of chemical industry.[178] German and American reports from 1910 and 1914 drew much more optimistic conclusions because they "looked at the chemical sector as a whole".[179] Cohen and Hoogewerff only regarded as relevant the "English" large-scale production of soda and sulphuric acid, and the "German" synthetic-organic industry. As such they restricted their definition to those types of industry that could be convincingly related to "academic expertise and personnel".[180] The example they refer to in their report is illustrative of their underlying image of the relations between science and industry: the discovery of alizarin in German universities occurred simultaneously with improvements in the educational system for technical chemists that made it more aware of the demands of practice. The Dutch science- and university-oriented perspective on chemical industry inevitably lead to their pessimistic views. The involvement of the chemical society in this research was an early attempt, fueled by Cohen, to initiate cooperation between industry and science. But the attempt reflected the ambiguity of this ambition: the interests of academic chemistry directed the 'pure' presuppositions. Similar to the discussions about technical education, the presuppositions of pure science lay behind the societal involvement of the society.

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[177] Ibidem, p.482.
[178] Homburg (1993); Somsen (1998b).
[179] Homburg (1993), pp.259-260.
[180] Somsen (1998b), p.144.

3. 1908-1914 Wider Scope & Narrow Focus

The interactions of Cohen with the audiences outside of his sphere of general chemistry changed in type and content after his appointments as professor in Utrecht and as president of the Dutch Chemical Society. First the ‘knowledge transfer’ was requested by very particular audiences, later he would impose the principles and interests of general chemistry on a more abstract level on the Dutch chemical community. From 1908 onwards I observe again a change in the public involvement of Cohen, as he widens the scope from the chemical world to Dutch culture as a whole. Especially in education debates Cohen challenged the dominance of ‘classically’ trained humanists by advocating the value of natural scientific training for the individual and society. It seems that this increased circle of involvement amounted however to further societal detachment rather than engagement of the university professor. Also in his relation to engineers the voice of the pure chemist became stronger, and he seemed to estrange himself more and more from the needs and capacities of his practical audiences. In various departments of the Royal Engineering Institute, as well as in court and politics, the emphasis on the purity of science had exclusive rather than inclusive effects. The resulting distance and opposition between pure science and culture manifested itself also in the post-mortem veneration of Van ‘t Hoff.

3.1 The education laboratory for society and civilization

In the discussions concerning the chemistry education at secondary schools Cohen connected esthetic and didactic values to the epistemological structure of his “modern” general chemistry. The axiomatic approach from general principles to particular phenomena appealed to the intellect and esthetic sense of the youth. There, he already hinted that this provided a certain “general development” that the old chemistry, the humanities nor engineering could level. In 1910 and

1913 Cohen expressed his views on general development in explicit relation to the cultural dominance of the humanities and implicitly to the educational predominance of the polytechnic college. These were instantiations of the continuing debate about educational reforms that circled around the relation between HBS, gymnasium, polytechnic and university, in which ultimately the future of society was at stake: what values, traits and skills are required and desired in a modernizing society?

3.1.1 Laboratory life and 'general development'

The discussion that took place between a medical scientist, a classicist and a physical chemist elicit the cultural abyss between the sciences and the humanities. Medical professor H. Burger revived the educational debates in the *Nederlandsch Tijdschrift voor Geneeskunde* in the beginning of 1910 with a series of articles titled *Onderwijsbelangen*, educational interests. The professor from the University of Amsterdam repeated the often heard plea for the direct admission to the faculties of medicine and science to all pupils from the HBS. He clothed his argument with statistical data in graphic representations in favor of the "modern" HBS education and at the dismissal of the "classical" gymnasium. Classicist, library conservator and theatre maker M.B. Mendes da Costa took offence at Burger's use of statistics to produce a "pretense of reliability".[181] In two articles in the daily newspaper *Algemeen Handelsblad*, Da Costa instead attached "much more value … to the subjective judgment" of fully authorized "men of high standing". He endorsed an opposition between scientific objectivity and humanistic subjectivity in this way, which made him agree with authoritative scientific and medical professors that judged the classical languages redundant for their disciplines. This opposition was also the ground for the authority claim of the humanities to the sphere of "*algemene ontwikkeling*",

[181] Mendes da Costa (1910a).

general development. It was simply "impossible" that natural scientists could judge what real development amounted to. Da Costa, as humanist with life-long experience in training high school pupils for state exams, presented himself as the expert. In his second article, Da Costa used this experience and authority to plead for reforms on the science faculty that would attend the proper general development of the students.[182] In that light, he claimed that a distinction had to be made between a traditional doctor degree aimed at careers in education, and a degree for "future practitioners". The difference would be that the first group, who would teach the next generation, demanded proper general development. For Mendes da Costa actual general development amounted to knowledge of the classical languages and training in traditional humanistic disciplines like philosophy and literature. Da Costa projected only direct access from a HBS to the university in case of students pursuing a 'practical' degree. It was his authoritative opinion about the organization of science education, and the underlying assumption about the priority of humanistic general development in particular, that prompted a sharp reaction from Ernst Cohen.

The opposition between the old "classical" and the modern "academic" education was central to Cohen's reaction, which he presented at a meeting of "academically trained" teachers in secondary education.[183] Cohen related this distinction to the meaning of modern science and classical humanities for society. Quoting Justus von Liebig, who introduced the education laboratory in Germany, he dismissed the national "pride and vanity" and disconnect from the "organic life of the state" that were the consequence of the cultural dominance of the humanities. He referred to another famous chemist, the Frenchman Marcellin Berthelot, to claim that the

[182] Mendes da Costa (1910b).
[183] Cohen spoke at the *Algemeene vereeniging van akademisch gevormde leeraren bij het middelbaar en gymnasiaal onderwijs* (General society of academically trained teachers in secondary and gymnasium education). Cohen (1910a).

humanities were not “in harmony with the necessities and practical needs of modern society”. Backed by these chemical authorities, Cohen stressed that natural science could offer what the humanities lacked: modesty, harmony with nature and use for society and for the individual. [184] Cohen not only questioned the authority of the humanities on an abstract cultural level, he also attacked Da Costa’s claim to expertise directly: “In one word: Dr. Mendes theorizes at the writing table about problems that are far removed from his own field.”[185] Here, Mendes da Costa violated the “12th commandment”: you shall not write about what you do not understand. [186] Mendes da Costa, a self-proclaimed “enemy of anti-criticism”, was displeased with Cohen’s “attack” and wrote him a letter directly and defended himself in a commentary in the same journal.[187] He reproached Cohen for using the 12th commandment as a rhetorical weapon and claimed that the chemist, “a practical man par excellence”, had refused to think deeper about Da Costa’s proposed reforms.

Their discussion received wider attention and sheds light on the cultural abyss that existed between scientists and humanists in society.[188] Both Cohen and Mendes da Costa presented themselves as modern, practical men, but they disagreed fundamentally on the meaning of general development. Cohen elaborated this in direct relation to the practice of his laboratory: “Those who know the daily life of the laboratory, know the deep impact it has on

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[184] Cohen (1910a), p.3.
[185] Cohen (1910a), p.5.
[186] The “12th commandment” was introduced by the Russian Jewish Orientalist Daniel Chwolson in 1906 to condemn Ernst Haeckel’s “suspicious and useless” attempt to conjoin natural science and philosophy. His typical modern demand for restriction to one’s “expertise” spread quickly and became a cultural aphorism for many scientists and philosophers. See for example Husserl (1952); Weber (1909).
[187] Mendes da Costa to Cohen, 7 April 1910. Bijzondere Collecties Universiteit Utrecht [BCUU], inv.nr. ADU9181:227, Verzameling overdrukken van artikelen, Verhandelingen 5. Mendes da Costa (1910c).
[188] E.g. “Akademische opleiding: Cohen versus Mendes da Costa.” *Algemeen Handelsblad*, avondeditie, Zaterdag 16 april 1910, p.2.

opinions and routines of the student".[189] The daily interaction with people sharing communal interests, the regular friction of thoughts and the colloquia that train presentation skills were all "a horizon widening experience" for the future teacher. Cohen regarded the writing of the dissertation also highly as one of the most formative periods in which not only the intellect but also the character was shaped. This was crucial for the development of the intellect and character of the teacher, and prepared him for his important task of shaping the minds and personalities of the next generation. Cohen presented the laboratory as a place of practice, were the manipulation and application of principles provided a modern form of general development. He invoked Goethe to substantiate this conviction: "*Es bildet ein Talent sich in der Stille / Sich ein Charakter in dem Strom der Welt*".[190] The laboratory was in this case the flux of the world and opposite to the silence and gloom of the writing table. This rather ambiguous rhetorical move by Cohen is characteristic to his reasoning. On the one hand, he presents himself as a 'man of culture' that is well-versed in the literary classics.[191] But on the other hand he is precisely using this cultural reference to claim the opposite: that without such humanistic knowledge one also obtains general development.

Cohen's standpoint in this debate relates to the changing public function of the university. In the nineteenth century universities' main task was to educate the future elite and endow them with the proper values and ideas (*Bildung*) that corresponded to their class position. By the end of the century, both society and education had democratized, and the universities primarily became a place to learn a profession, and prepare for a career in science or society.[192] This latter progressive, democratic function and the former reactionary character formation are two

[189] Cohen (1910a), p.6.
[190] "One develops one's talents in silence/ One's character in the flux of the world". Cohen (1910a), p.9.
[191] Lenoir (1997), p.13.
[192] Bank & Van Buuren (2000), pp.267-269.

different roles for the university in society. Cohen's representation of his laboratory as educative space was an ambiguous combination of the two that shows that the nineteenth century ideal of *Bildung* had not completely disappeared. The ethical and esthetic elements for general development could be acquired in the study of physical chemistry in the practical and social surroundings of the "Temple of Science": a sense of nature's harmony and a disciplined, cooperative and practical attitude. The experience of the laboratory life was the best preparation for the "struggle for existence" that awaited the youth in modern Dutch society.[193] This representation of the value of general chemistry was not incoherent with his remarks between 1904 and 1906. But, the scope of application of his ideas increased from high school chemistry education, to society at large. His focus shifted a bit to the modern natural sciences as a whole, and he actively opposed this to the classic humanities, to break their dominance in many cultural spheres. As the scope and the opponent changed, Cohen shifted the emphasis in the representation of science from rational and deductive to the *Bildung* it provided.

3.1.2 University science as 'goddess' and as 'cow'

In 1913, Cohen emphasized the newer 'democratic' function of the university by explicitly presenting the education laboratory as the ideal preparation for the awaiting societal struggle. At the ten year anniversary of the NCV, Cohen, again president of the society, titled his speech "*Non vitae, sed scholae docemus*": Not for life, but for the school we teach.[194] Seneca originally used this phrase to anticipate (and attack) a complaint for more practical education instead of the study of literature. Many schools quoted (and quote) unknowingly the inversion of Seneca's quote to stress the use education has for life. Cohen, ultimately, furbished his own

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[193] Cohen (1910a), p.12.
[194] Cohen (1913).

original version: "*Et vitae, et scholae docemus*". In front of the Dutch community of academic and practical chemists Cohen argued that the university prepared both for careers in science, education and industry. As such, it supplements his arguments about general development above. This time, however, he did not distinguish science from the humanities, but rather attempted to associate chemical science directly with the world of practice.

Cohen deducted from the law on higher education of 1876 that academic education had to relate to two "categories of our spes patriae" (hope of our nation, i.e. the youth). Again he used a German nineteenth century poet to illustrate his point. He quoted Schiller on "Wissenschaft" to depict how these two groups related to science: "*Einem ist sie die hohe, die himmlische Göttin, dem anderen / Eine tüchtige Kuh, die ihn mit Butter versörgt*". [195] Those students that pursued their careers in independent scientific research (corresponding to 'school'), the smaller group, were "priests of the heavenly goddess". The largest group of students was prepared for "scientific occupations" in society (corresponding to life), like secondary education, industry and government laboratories.[196] For them, science was an efficient milch cow. In this way, Cohen left no doubt which of the two he considered more honorable and morally high-standing. This opposition relates to contemporary understandings and representations of science in France and Germany. The opposition between atomism and energeticism amounted in France to different worldviews: the atomist approached the world as "artist" and the energeticist as "engineer".[197] In Germany the artistic related to the "old" nineteenth century image of science, while the engineer embodied the twentieth century promise of science.[198] The almost self-evident atomism in Dutch natural science at the turn of the century makes that they cannot be easily divided in to these two

195 Ibidem, p.5. 'One is the high, the heavenly goddess, the other/ an efficient cow, which nurtures you with butter.'
196 Ibidem, p.7.
197 Bensaude-Vincent (2005), pp.20-27.
198 Ziche (2005), p.31.

camps. Cohen reformulated the artistic and the engineer world views into two complementary roles science played in society.

Cohen presented his article as plea to other Dutch science faculties to adopt the reforms he established in Utrecht. Even though his preference for the artistic goddess was evident, he restructured the pedagogical approach in Utrecht because the “rigid scientific and theoretical training” was not preferable for the practically oriented students. The science faculty initiated a significant reduction in the study period by attuning the exam demands to the “particular talents of the individual”. The students heading for industry could cut back on physics and mathematics which, although essential to modern general chemistry, were often not required for their future “daily recurring work”. As a consequence, the students would enter society “in the best of spirits” at the age of 24, “not depressed by needlessly heavy exams and completely educated in the spirit of their natural aptitude”.[199] These reforms, and Cohen’s accompanying rhetoric, appear to correspond with “process-education” as university chemistry was individualized to connect better to professions in society.

Compared to his advice about HBS education in 1905, Cohen also appears to have shifted opinions. Instead of reforming the outside world on the basis of his general chemistry, he adapts and opens up the university to society. Still, it is odd that he presents precisely these reforms alongside a clear moral hierarchy between science as goddess and as cow. It becomes understandable, however, when an implicit motivation of Cohen is highlighted by chemical engineer R.A. van Sandick.[200] In *De Ingenieur* he wondered “with astonishment” whether the “learned speaker [had] deliberately overlooked the numerous chemical engineers”, because from

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[199] Ibidem, p.13.

[200] Sandick, (1913). ‘*Geleerd*’, learned, carried the connotation of a nineteenth century ideal of the scientist as ‘bearer of culture’, rather than man of practice.

his speech it was impossible to “deduce that there also exist technologists” in the chemical and Dutch society. By referring to Cohen as ‘learned’, Sandick characterized the university chemist as a nineteenth century ‘bearer of culture’, rather detached from the world of practice. The reforms that had to connect university education better to society were an implicit, but direct affront to the polytechnic school in Delft. Cohen’s presentation of his views as a concession to the practical needs of society holds within the context of his faculty, university and the ‘academic’ audience of the Dutch Chemical Society. But in the national context of the Dutch higher education system and before the audience of *De Ingenieur,* it is above all an effort to strengthen the position of the schools of the goddess in opposition to those of the cow. This attempt of Cohen to expand the societal meaning of academic education connected to a wider discussion about the use the university had for the futures of the students. G. Hondius Boldingh for instance, at his 1909 installment as professor in analytical and pharmaceutical chemistry in Amsterdam, specifically criticized the educational overemphasis on pure science.[201] But Cohen, a pure chemist above all, made sure to accompany his strategic argument for better connections between university and society with a clear rhetorical image in which academic chemistry had moral priority over the world of practice.

3.1.3 Enlightening the Dutch East Indies

Cohen prioritized university education in the natural sciences over the general education a technological and classical training provided. In 1912, Charles van Deventer would add to that a strict separation between science and religion. Van Deventer had returned, in 1909, from the Dutch East Indies to work his way back into the scientific and cultural world of the Netherlands. By 1911, he worked with Cohen in the Van ‘t Hoff laboratory and by 1913 he was the scientific

[201] Snelders (1997), pp.32-35.

and philosophical editor of the monthly *De Gids*. The abolition of the generation of ’80 opened the opportunity for *De Gids* to slowly rebuild its role as voice of the cultural elite.[202] In the first decade of the new century it was still a “professorial” journal that adopted a “general liberal stance”.[203] The 1895 appointment of the zoologist A.A.W. Hubrecht to the editorial board resulted in a stronger focus on contemporary developments in the sciences. Van Deventer succeeded him as scientific and philosophical editor in 1913. He only held this position for a short period of time – his deafness was reason of withdrawal – but remained closely associated with the editorial board and assessed most scientific and philosophical articles. In these years the amount of admitted articles was “enormous”, demonstrating that the journal’s social spread and cultural importance were increasing.[204] Van Deventer used his literacy in the sphere of science and culture to address the relations between the two.

An early example is a public debate about educational reforms in the Dutch East Indies in which science and religion became opposed. Van Deventer inveighed strongly against the theologian, professor and Senate member Herman Bavinck. In December 1911 the neo-Calvinist politician declared in the Senate that “natural science, although it may sound paradoxical, has to thank its origin to Christianity and cannot be untied from it”.[205] The idea itself was not particularly new, but what offended Van Deventer were the location of his statement, his intention to let it “weigh on government policy” and his authority as professor. It was a very meaningful cultural event when a professor in theology conflated religion and science by historical argument in Senate discussions on education in the Dutch colonies. Everybody agreed that Western culture in the form of natural science had to “enter the Indies”, but the issue was

[202] The generation of ’90 found a new communication channel in *De Kroniek*. Bank & Van Buuren (2000), p.151.
[203] Aerts et al. (1987), pp.107-108.
[204] Ibidem, p.114.
[205] Van Deventer (1912), p.481.

whether this would occur with or without the historical narrative and moral system of Christianity.[206] The chairman had not dared to question Bavinck's authoritative confessional representation of science, and instead asked Van Deventer to asses this statement. In this situation he was obviously an expert, as his knowledge of natural science and classics self-evidently combined. And for him it was clear: "facts are facts…the first proper natural science emerged in pagan Greece".[207] He characterized Bavinck pejoratively as a "conquistador" who would have to destroy many "heroic characters" in history to stand by his claim. As the transition from pagan beliefs to monotheistic Christianity took ages, and "we want to do it quicker than centuries in the Indies", Van Deventer advocated to place natural scientific education under the protection of "the enlightenment…the idea that phenomena are to be explained by natural causes".[208] Also in later publications, Van Deventer often used enlightenment as positive characterization of science, representing this sphere as rational, just and progressive. Similar to the theme of purity, this could put science in contrast to other traditional, conservative and dogmatic spheres, like religion. In the debate with Bavinck, Van Deventer presented science as a representative of the core cultural values of The Netherlands. In this representation, science was also able to replace religion in moral and social dimensions. Science was culture and therefore central in the 'enlightenment' of the indigenous people of the Dutch Indies.

3.2 Too pure chemistry for practice

In 1902, engineers had cherished "hope" that Cohen would not become "unfaithful to technical chemistry".[209] Through the years, however, the academic chemist grew apart from the engineering community. For almost a decade, Cohen did not interact directly at meetings of the

[206] Flipse (2014), pp.99-100.
[207] Van Deventer (1912), p.482.
[208] Ibidem, p.489.
[209] *De Ingenieur*, 17 (1), p.17

Royal Institute of Engineers. In February 1908, the president of the department of electro technology characterized his “useful and pleasant” lecture on the mechanism of the Daniell element a ‘successful’ “rentrée en scène”. [210] Cohen justified his renewed presence in the world of engineering with John Tyndall’s metaphor: “science and applied science are coalesced like a tree with its fruits”.[211] This image of the tree depicts science as strongly grounded in nature, and directly bringing forth the fruits of technology, that can be consumed by humanity. By depicting technology as applied science, he connected the world of engineering directly to his science, while also representing it as a strictly linear relation. Between 1908 and 1910 Cohen actively communicated his scientific research again to the audiences of electrical, mechanical and shipping engineers, but his attitude towards, and awareness of, the practical audience had changed, reflecting his greater attachment to the international academic world of chemistry.

3.2.1 Standard elements

The “success” of Cohen’s comeback, as acknowledged by the president of the department, was undoubtedly part of habitual rhetoric towards a distinguished member of the society.[212] The scientific research that Cohen reported on in February 1908 lacked any clear practical implication. From the turn of the century Cohen paid much scientific attention to the electrochemistry and thermodynamics of the “standard elements”. Standard elements were galvanic cells that produced a stable voltage and were used in laboratories and industry to calibrate electrical equipment and circuits, mainly voltmeters. The widespread use of standard elements in an electrifying society made the topic particularly relevant to electrical engineers.

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[210] ‘Het mechanisme van het Daniell element’, *Bijblad Vakafdeeling voor Elektrotechniek*, 25, in: *De Ingenieur*, 23(18).

[211] The reporter picked up the strong metaphor and included it in the summary. ‘Vergadering van de afdeeling voor werktuigen en scheepsbouw van het Koninklijk Instituut voor Ingenieurs’, *De Ingenieur*, 23(19), pp.349-351.

[212] Het mechanisme van het Daniell element’, *Bijblad Vakafdeeling voor Elektrotechniek*, 25, in: *De Ingenieur*, 23(18).

His first communications to electrical engineers in 1898 and 1899 related to the practical use of these elements.[213] He presented especially the research in cooperation with experimental physicist Philip Kohnstamm as potentially “very valuable” for practice. Their investigations of the minor deviations in the temperature coefficient of the Weston element could disprove it namely as practical standard. The crystal structure changes that occurred below 15 ºC – their explanation of the deviations – would not prevent the Weston element to become the international standard from 1911 until 1990. Still, their practical recommendations made sense: use the element above 15 ºC and in “a hot engine room…in the proximity of boiler flues” it was definitely the best element available.

At his ‘rentrée’ Cohen, and two English collaborators, presented research which was primarily scientifically motivated. They had constructed the “complete thermodynamics” of the Daniell element which could “not be considered a standard element anymore” because it had fallen out of use.[214] Although they concluded that a Daniell element with saturated solutions could be similar in quality to the more current Clark and Weston elements, the research lacked any direct practical relevance. In his last lecture for electrical engineers, in 1910, Cohen demonstrated that he had kept up with developments in practice, but above all in the international context of standardization.[215] His scientific investigations related to the results of public technical-scientific research institutions, like the American *Bureau of Standards* and the *Physikalisch-technische Reichsanstalt,* and to international organizations like the *International Conference on Electrical Units and Standards.*[216] Cohen argued for the engineering audience that the temperature formula developed by this conference was false, and pleaded that his correct

[213] Kohnstamm & Cohen (1898); Cohen (1899).
[214] Cohen (1908a), p.334.
[215] Cohen (1910c).
[216] Cohen (1910c), pp.787, 789.

formula would be adopted. Apparently, he required the argumentative force of practical support to convince the international community. His attempt to raise their support was successful, as the engineers decided in 1911 to send in a contribution about this issue to the *Comité International des tables annuelles physico-chimiques*.[217] Cohen mobilized the engineering community to contribute to this scientific goal and to his reputation in the committee, of which he was a member since 1909.[218]

In these four lectures for the electrical engineers a transition is observable from a clear and concrete orientation to the problems of practice towards a scientific disengagement with the practical realm. First, Cohen drew problems from practice and presented his results as relevant to this realm. Later his topic choice is strictly scientifically motivated and lacked any direct correspondence to a practical problem. Upon conclusion, when the world of practice was about to agree formally on a standard, Cohen's scientific contribution is a denial of this reality. Instead of responding to a practical problem, he now attempts to mobilize practical support for his international scientific aims and reputation. Through the years it becomes clear the Cohen's scientific concept of utility, which is based on experimental exactness and purity, diverts from the practical use of the standard elements and the underlying pragmatic concept of reliability.

3.2.2 Metaldiseases

Cohen's activity in *De Ingenieur* revived with topics that dealt im- or explicitly with purity. He aimed to show practice that the widely used Weston element was actually, from a scientific and experimentally exact point of view unreliable, impure. That same year he also reported for the first time about "metaldiseases" to an audience of engineers. In the context of a culture

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[217] 'Jaarverslag'. *De Ingenieur*, 1911, 34. *Bijblad Afdeling elektrotechniek*, p.36
[218] Cohen (2013), p.101.

determined by a desire for purity, "a concept of disease is never innocent".[219] It is a convenient metaphor to mark distinctions and to define purity. In this situation it is Cohen's general chemistry that defines (im)purity, and the outside world of metals that is contaminated. The medical representation of physical-chemical properties of metals could have been a way for Cohen to increase the urgency for practice and stress the potential of science as the curer. This medical representation of physical chemical problems and the implied progressive representation of science as healer, self-evidently connects 'pure science', progress and purity.

In front of the meeting of the department for mechanical and ship engineering Cohen spoke about "tinpest and museumdisease".[220] This is the first time that he discussed the allotropy of tin outside of a scientific context, even though he had been investigating this subject for over ten years. In *De Ingenieur* he referred to that series of scientific publications but promised that he would also show that there was "an important technical side to this problem". He reported previous, unsatisfying explanations and many different instances of tinpest and museumdisease. These examples he drew from scientific literature, archeology and practice: he did a survey amongst museum directors, organ pipe manufacturers and numismatists.[221] They all confirmed experience with the phenomenon of tinpest: odd lumps and bumps that seem to grow spontaneously on tin artefacts, the appearance of holes in the tin, or the sudden complete decomposition of tin materials. Rather elaborate, Cohen spoke about his own experimental investigations into the allotropic state of tin in which he determined the transition point from the white to the gray modification of tin at 18 ºC. The allotropic modification below that point had a greater density, thereby causing the 'plague spots' on, or the complete decomposition of, the

[219] A quote by Susan Sontag. Labrie (2001), p.18.
[220] Cohen (1908b).
[221] Cohen (1908b), pp.535, 537.

material. He related his scientific perspective to the everyday explanations from practice that still ascribed the phenomenon to chemical impurities. Pure science learned that also chemically pure tin demonstrated the ‘illness’, and that it was thus rather due to physical impurity, i.e. a metastable modification of the material. The recommendation to museums was to store all artefacts above 18 ºC to prevent decomposition, even though he himself also admitted that the transformation could easily take centuries.[222] He concluded the medical metaphor of the metaldisease when he formulated this advice as “it is better to prevent than to cure”.[223]

Two years later he again ‘diagnosed’ a metastable condition of metals, unrelated to the tinpest, as an illness: the “forcing disease of metals”.[224] Metals that experienced force, by pressure or pulling, would turn into a metastable state. Forced metals could therefore be considered as in a continuous process of recrystallization into the stable, unforced state. This process was accelerated when stable metal was “grafted” onto the metastable, forced metal. Or, to use his medical metaphors again, the forced metal could be “infected” by unforced metal.[225] Cohen illustrated, in conclusion, unwanted practical consequences of this phenomenon. For example, he discussed the decomposition of petroleum lamp reservoirs at a factory in Berlin that especially occurred when moved from a cold storage to a warm house setting. The higher temperature accelerated the recrystallization process, as did the increased pressure of a new factory forcing method. Also everyday objects like tin-coated cans and brass doorknobs were victims of the forcing disease – actually “all metals that experienced mechanical treatment

[222] Recent historical research has questioned the usefulness and reliability of these practical recommendations. Mark Gilberg, a museum conservator, has stressed in 1991 that Cohen’s scientific research on the tinpest “grossly exaggerated” the effect on museum objects. Ultimately this even led to many false observations of the tinpest where it was actually ordinary oxidation, so that many “inappropriate measures” have been taken for the conservation of those museum objects. Gilberg (1991).
[223] Cohen (1908b), p.536.
[224] Cohen (1910b).
[225] Ibidem, pp.353-355.

demonstrate the forcing disease". This provided ground for Cohen to claim that "these results are highly interesting with regards to their application to technological problems".[226]

In both lectures on metal diseases, Cohen presented his scientific research as directly relevant to technological practice. He also admitted that he was motivated by "some sort of egoism".[227] He emphasized the close connection between physical chemistry and engineering by asking for reports of similar practical experiences with metals to "contribute to the knowledge of phenomena in this area". The engineers that contributed to science could "expect heartfelt gratitude". [228] This happens around the same time that he also commenced his mobilization of electrical engineers for his internationalist endeavors in standardization. The data Cohen hoped to collect, served the purpose of furthering his own scientific research. At this point in time he is cautiously expanding the scope of his allotropic investigations from selected metals to the metastability of the "metalworld" and ultimately the "entire world".[229] The audience of engineers carried a huge potential of empirical experience and practical knowledge of materials that could guide his scientific way forward.

But the criteria of pure science were also applied to the engineers' practical experience. This becomes clear from the discussion that followed his 1910 lecture with Professor P.D.C. Kley and engineer E.B. Wolff.[230] Kley, a teacher in microchemistry and metallography at the polytechnic college in Delft, questioned Cohen's descriptions of recrystallization. He reported that the phenomenon was unknown to metallography and that they "had not been able to observe it".[231] "It *is* this way" replied Cohen to the technical chemist and he stressed that the proper conditions,

[226] Ibidem, pp.356-357.
[227] Cohen (1910b), p.349.
[228] Cohen (1908b), p.539; Cohen (1910b), pp.349, 357.
[229] Respectively Cohen (1914); Cohen (1921a).
[230] De Ingenieur, 25(9), Bijblad: Afdeling voor Werktuig- en Scheepsbouw, 31, pp.166-168.
[231] Ibidem, p.168.

like a high temperature, were required to produce the phenomenon. Kley responded by opposing the interests of practice to the detached science, which amounted to a scientific and a practical sense of 'reliability': "I would just like to point out, that our bridges and railways, although completely metastable and thus unreliable from this perspective, as yet will not collapse, because the metastable state is very often completely without danger". Also Wolff, who worked at the laboratory of the *Koninklijke Fabriek van Werktuigen en Spoormaterieel* in Amsterdam, added that the phenomenon was not known to him and would question the danger Cohen ascribed to 'infection' of metals.[232] He believed that the "common use in practice to glow out metal" prevented the forcing disease from appearing. Cohen, even though he did not consider himself enough an expert in metallography, replied that the glowing had to take place at a temperature high enough, above the transition point, to resort effect. He agreed that this could be established in practice but also implicitly justified the practical importance of his own science that consisted of the experimental hunt for transition points.

Overall, Cohen's request for practical experience appears to be a rhetorical strategy to interest his audience and stress the interweaving of science and engineering. Cohen used the rhetorical image of a scientific tree with technological fruits to justify the importance of science for engineering and industry. From the reactions becomes clear that the two worlds were much stronger separated than he sketched in his hierarchical, organic image. There was a rift between the experimental experience of Cohen and the practical know-how of the engineers. This also made Cohen exaggerate the impact of his results because, again, he fostered a concept of reliability far too exact – or 'pure' – than what practice actually required. The medical representation of physical chemical problems connects to this, as it was a way for Cohen to

[232] Royal Factory of Machines and Railwaymaterial. Ibidem; Wolff (1910).

convince his audience of the relevance of his science. Ultimately, however, the metastability, infection or illness of the entire world was less a problem for practice than Cohen wanted his audience to believe.

3.2.3 Cohen in court: scientific expertise in practice

In his autobiography Cohen claims to have served on a regular basis as expert in court cases.[233] In 1897 and 1898 he served twice as counter-expert in court cases upon request of the defense, and in both cases the inconclusiveness of the experts' disagreement would lead to the acquittal of the suspect. In 1897 Cohen served as counter-expert in the case of lieutenant H.A. Zeegers, who was accused of poisoning the grandfather of his wife with "sublimate", mercury chloride.[234] Zeegers claimed that he used the sublimate in his possession for the development of photographs, but expert reports disproved this claim because they did not find mercury on his pictures. Cohen, both a professional chemist and an amateur photographer, was called by the defense to assess the evidence. He considered the value of the "(apparent) comparative research" of the experts "completely illusory", not the least because they were not up to date with the latest scientific developments in photochemistry.[235] Ultimately, the court shared Cohen's scientific skepticism and acquitted the lieutenant Zeegers for the lack of convincing evidence.[236]

In 1898 Cohen acted as counter-expert in the case "Meerenberg", a madhouse near Haarlem.[237] A patient was severely burnt after a too hot bath and would decease several days later. The nineteen year old nurse, E.J. van Steen, who bathed the patient was accused with

[233] Cohen (2013), pp.67-68.
[234] Cohen (1897).
[235] Ibidem, pp. 5-6.
[236] 'Rechtszaken. Vergiftiging.' *Algemeen Handelsblad*, 24 March 1897, p.1; 'Rechtszaken.' *Middelburgsche Courant*, 15 April 1897, p.1; 'Nieuws uit Nederland.' *Soerabaijasch Handelsblad*, 13 May 1897, p.2.
[237] Cohen (2013), p.68.

"inflicting grievous bodily harm".[238] The witnesses heard for the prosecution – physicians from Meerenberg – doubted whether the hot bath alone was the cause of her death and instead mentioned the patient's 'weak heart'. The counter-expert for the defense, medical professor Hector Treub from Amsterdam, questioned instead the burning all together, pointing to the fact that the patient was still able to use a cup of coffee and a bun after the incident. Cohen joined this skepticism with an analysis of the hot-water system of the institute. With an elaborate chalkboard drawing in the courtroom he demonstrated that the water impossibly could have been dangerously hot. Thereby he disproved the madhouse's director-physician Dr. J. van Deventer's "impure test", who maintained that the fact of burning was "indisputable".[239] The judge acquitted the young nurse because she was not responsible for the extreme temperature differentiations of the hot-water system.[240] It remained an open question who could be held responsible for this recent change to the water system: the architect, the director or the committee of supervision.[241] This issue got some more attention in the following weeks, and the counsel for the defense, mr. J.A. Levy, shunned the attempt of director J. van Deventer to put the blame publicly on the nurse.[242] Almost victoriously, Cohen described in his autobiography how this director did not appreciate his criticism and blocked his membership to the learned society *Hollandsche Maatschappij der Wetenschappen*.[243] Ultimately, the counter-expert reports of Cohen were not decisive in the court's decisions, but they were instrumental in disputing the expert reports and raising general skepticism. Cohen did not offer a clear-cut answer, but rather

[238] 'Rechtszaken. De zaak 'Meerenberg' voor het Hof.' *Algemeen Handelsblad*, 14 July 1897.
[239] Ibidem.
[240] 'Rechtzaken. Veroorzaking van dood door schuld.' *Het Nieuws van den Dag*, 15 July 1897.
[241] 'De zaak van 'Meerenberg'.' *Algemeen Handelsblad*, 15 July 1897.
[242] 'De zaak Meerenberg.' *Algemeen Handelsblad*, 25 July 1897; 'De zaak Meerenberg. Eens van een ander standpunt bekeken.' *Algemeen Handelsblad*, 31 July 1897.
[243] 'Dutch Society for the Sciences'. Cohen (2013), p.68.

introduced scientific doubt. Like his concept of reliability differed from the engineers, so did his contribution in the court make a different concept of certainty manifest.

The court appearances of physical chemist Cohen were highly value-laden. Cohen condemned the sphere of law for the lack of natural scientific knowledge which had been “at the advantage of many criminals, at the disadvantage of society”.[244] Also, he often experienced opposition to his natural scientific values of veracity and agnosticism. One court-case especially received wide attention in the newspapers and opposed Cohen’s pure science to the practice of law, apothecaries and secularization. In 1910 Cohen served as counter-expert in the court case of the Italian fraud Giuseppe Zerbino, who was sued for the possession, spending and exchange of “violated” English pounds – gold had been extracted by chemical methods.[245] Various elements of the general chemist Cohen in Dutch society combine here. Cohen was inspector at the Dutch Royal Mint in Utrecht, which was the background for his appearance as expert. Probably it was his friend and national Master of the Mint, C.P. Hoitsema, who recommended him. As counter-expert he, furthermore, distinguished his scientific chemistry explicitly from the unscientific apothecaries that drafted the first report. They had defended a “half a century old” opinion on the means of extracting gold from coins, did not accurately reproduce the practices of a money violator and their report did not meet Cohen’s scientific criteria of transparency, certainty and reproducibility.[246] It was “very disappointing” that this type of investigations were not sent to “pur sang chemists”. One of the expert apothecaries defended himself by saying that, although he was aware of the more modern methods of violation, he only included those that lay within the “reach of normal humans”. The prosecuting attorney summarized the expert controversy the next

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[244] Cohen (1919), p.14.

[245] ‘Muntschennis.’ *Algemeen Handelsblad*, 27 October 1910, p.8; ‘Muntschennis’, *Algemeen Handelsblad*, 11 November 1910. ‘De Italiaansche geldsnoeier’; *De Tijd*, 10 November 1910.

[246] ‘Muntschennis.’ *Algemeen Handelsblad*, 27 October 1910, p.8.

day: “they still disagree…but they do agree that … [the first expert report] was not far from the truth”.[247] Again, a conflict emerged between Cohen’s high standards of ‘pure science’ and the practical world of justice where these standards did not strictly apply.

Lastly, his scientific expertise intersected with his agnosticism. “Even though he was born out of Israeli parents”, Cohen took the oath “bareheaded” and declared upon request that he did not belong to any church.[248] The court retreated in the judge’s chamber to discuss this unusual event. They decided, that “expert” Cohen could not be heard under oath when he maintained his refusal to cover his head. Therefore, they proposed to hear him without it. Just a week later Professor Johan Wertheim Salomonson also swore an oath in the courtroom bareheaded and defended his decision with reference to God.[249] Salomonson entertained a “warm friendship” with Cohen, which makes the mutual influence probable.[250] The similarities of these two “oath issues” were noted in the daily newspapers.[251] A. Duparc argued that any legal foundation was missing for the decision in both cases to declare the bare-headed oaths invalid. The Jewish religion prescribed, ultimately, no such obligation. The absence of legal ground was “even more the case” for the agnostic Cohen. Where his pure perspective was dismissed in the judge’s decision about Zerbino, it did hold in his secularized appearance in the public arena of the court.

3.2.4 Van Deventer and the use of science for society

Also Charles van Deventer related physical chemistry as pure science to the world of practice. During his stay at Cohen’s laboratory, Van Deventer developed a, rather popular,

[247] ‘Rechtszaken. Muntschennis.’ *Algemeen Handelsblad*, 28 October 1910, p.6.
[248] ‘Rechtszaken. Muntschennis.’ *Algemeen Handelsblad*, 27 October 1910, p.8.
[249] ‘Rechtszaken. Overtreding algemene politieverordening.’*Algemeen Handelsblad*, 1 November 1910, p.1. This case concerned itself with the display in a shop-window of several books that “titillated the sensuality” of the youth.
[250] Cohen (2013), p.41.
[251] ‘De eedsquaestie’. *Algemeen Handelsblad*, 9 November 1910, p.9. Also reprinted in *De Leeuwarder Courant*, 11 November 1910.

course on the history of chemistry. In two articles in *De Gids* his historical interest combined with the science of Cohen. In the '*Luimen der Metalen'* (Moods of Metals) and '*Goudbepaling in oude tijden*' (Gold determination in old times) Van Deventer combined his classical interest with physical chemistry by discussing, above all, antique coins.[252] He presented physical chemical investigations on metals in the historical context of the monetary system so that it gained cultural significance. In an article from 1913 the positive impact of science on society is less evident and could only be achieved by distinguishing it from industry. He discussed the social problem of gas intoxication, which had caused many casualties in Dutch homes. The existing industrial methods that lowered the quality and increased the toxicity of gas made Van Deventer exclaim: "I am afraid your esteem for science and technology is not increasing".[253] He first published his discussion on improvements in toxicity and safety of domestic gas use in June 1913 in the *Chemisch Weekblad.* After the reaction of a chemical engineer, Jan Rutten, he realized the topic was not only of interest to chemical professionals, but also required the support of a broader audience in Dutch society. To that end, he republished the article in *De Gids* five months later. Although Rutten, who held a position at a gas factory, disagreed with the cost calculations of the academic chemist, he did agree that the problem was the strategic refraining of industrial producers from informing their clientele of the dangers.[254] In *De Gids* Van Deventer attacked this "ostrich policy" head on. To achieve change, to obtain non-toxic lightning in all the Dutch homes, "public opinion" had to be mobilized: the audience of *De Gids* was asked to convince their local councils and factory directors to set "rational demands" for the production of gas. Not only did Van Deventer explicitly demand financial public support by stressing the social utility

[252] Van Deventer (1914b; 1916).
[253] Van Deventer (1913).
[254] *Algemeen Handelsblad*, 09-06-1913, p.6.

of science, implicitly he also distinguished the interests of the university from industry. The factory directors were irrational and immoral, and had to be democratically restricted by the rational, social and moral demands of science. In this issue of practical enlightenment, Van Deventer repeated, implicitly, his representation of science in society as the 'enlightened' sphere of rationality, only this time in distinction to the immoral world of industry and trade.

3.3 Cultural depreciation of pure science

"A goldmine for the intellectual life of the city and the nation" had been lost with Van 't Hoff's move to Berlin in 1896.[255] Already in 1900 Cohen expressed his admiration for his teacher in the *"Mannen en Vrouwen van Beteekenis in onze dagen"* series, which directly staged the scientist as an international and cultural persona.[256] To this general literate audience with interest in elite culture, Cohen repeated Van 't Hoff's demand that not only education but also research had to be embedded in the law as "national concern".[257] Van 't Hoff's departure for a research position at the Prussian Academy of Science was for the Cohen the sign that the Dutch "layperson" often lost sight of the eventual benefit pure scientific research would have for "practice [and] national welfare".[258] For the general chemists in the Netherlands Van 't Hoff was of central importance to the cultural legitimation of their disciplinary identity. In line with the Dutch cultural nationalism, the veneration of historical geniuses and the scientific self-confidence, they used Van 't Hoff to stress science as an indispensable element of national culture.

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[255] Cohen (1900), p.34.

[256] 'Men and Women of Importance in our days'. For example, the same issue contained descriptions of Dutch physicist J.J. van der Waals and botanist H. de Vries, the Belgian poet Georges Rodenbach, the Spanish politician Emilio Castelar and French painter Puvis de Chavannes. Ibidem.

[257] Van 't Hoff had uttered this demand in 1895 at the Dutch Congress for Natural science and medicine (NNGC). Ibidem, pp.33-34.

[258] Ibidem, pp.8-9.

The untimely death, in 1911, of the first Noble prize winner in chemistry was occasion for many of his former students to repeat the demand for more public appreciation of science. Van Deventer wrote an elaborate obituary notice in *De Gids* for his previous teacher and boss.[259] Cohen wrote obituaries for *De Ingenieur*, the *Chemisch Weekblad*, daily newspapers and directly started working on a biography which was published in 1912.[260] The national appreciation for the Noble prize winner did not correspond to the veneration of his former students. Both Cohen and Van Deventer defended their scientific hero from accusations of "vanity" and arrogance. These sentiments originated in the situation that surrounded his Berlin departure. Van 't Hoff was offered the position in Berlin, but also took an Amsterdam counter-offer in consideration. Some had seen pride and vanity in his move, as he had recently obtained a new laboratory funded by public money. Cohen, however, framed it as "bureaucratic shortsightedness" of the Dutch government that reflected a lack of appreciation.[261] The physicist H.A. Lorentz, who was of at least as high scientific standing as Van 't Hoff, countered this opinion in private correspondence and publicly in the *Chemisch Weekblad*.[262] ". They both agreed that Van 't Hoff's demand for a "fully government funded position", avoiding dependency on particular funds, was just. That the autonomy of science was a public concern was out of the question. But, Lorentz demanded a public withdrawal because Cohen had "gone too far" with his condemnation of the Dutch government as narrow-minded. Instead, Lorentz judged the attitude of the Netherlands as "with the best of intentions and with love for national science". Although the two men agreed in principle on how society had to support science, they were radically opposed in

[259] Van Deventer (1911).
[260] Cohen (1911; 1912a; 1912b; 1915b); *Nieuwe Rotterdamsche Courant*, 17 April 1915.
[261] Cohen (1915b), p.408.
[262] Lorentz (1915); Boerhaave Archives Leiden [BAL], inv.nr.a96, Manuscript Autobiography E. Cohen; Lorentz to Cohen, 13 May 1915; Cohen to Lorentz, 17 May 1915, pp.58-64.

the way they framed the attitude of the state and the cultural appreciation of science. This suggests that Cohen's pessimistic representation of science in Dutch culture was a rather elitist strategy to further increase autonomy and support for science.

Van Deventer, addressing the cultural elitist audience of *De Gids*, explicitly presented Van 't Hoff as a "pure" and "exceptional" Dutchman, whose fame "*we* will carry".[263] His long devotion to the establishment of his Amsterdam lab that "upholds the honor of national chemistry", had rid him from the "moral obligation" to stay in place.[264] Selfish motives he did not ascribe to Van 't Hoff: all he did, was for the "blossoming and fame of his *field*" and for "the enlightenment of himself and of humanity".[265] Science was for him not only a good cause in itself and a "glorious support to culture" but also a love "like an artist loves his art".[266] Van 't Hoff and his science were presented as enlightened, as an indispensable and integral part of Dutch culture, and similar to the stature of art. Although Van Deventer staged him as having respect for all areas of culture, his "manly religion" was a profound scientistic one: "the sacred conviction that science can, will and has to fight darkness".[267] Here the association with religion represented enlightened science as a moral framework for life. Like Socrates, Van 't Hoff was an "eccentric character" that longed for enlightenment of the self, humanity and world – who was perhaps not always understood in the Agora. Van Deventer went out of his way to rehabilitate this scientific Socrates and his importance for Dutch culture. In this way Van Deventer represented science, with Van 't Hoff, as the eccentric intersection between the individual genius and the cultural community.

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[263] Ibidem, p.138.
[264] Van Deventer (1911), pp.147-149.
[265] Ibidem, pp.147, 154
[266] Ibidem, p.148.
[267] Ibidem, pp.150, 154.

4. The Catalytic Effects of a World War

In 1914 Van Deventer wrote in *De Gids* that for “a great mass of civilized people” natural science was no longer the “enlightening dream of truth”.[268] In 1887 he had still described Van ‘t Hoff’s laboratory in Amsterdam in poetic terms as a “mystical place” where there was something “demonic in the air”, namely the insight in the truth of the analogy between physical and chemical phenomena.[269] As the new century progressed the artistic ideal of science, or the heavenly goddess, was increasingly replaced by the engineering ideal of science, the milch cow. Even Van Deventer, who so often represented science with reference to enlightenment ideals of rationality and social progress, concluded in 1914 that “nothing more” remained than a “very beautiful” profession, “useful” for technical applications and money-making.[270] Between 1900 and 1914 the interactions of the pure general chemist Cohen with the various public audiences also changed. From practical requests for the perspectives of pure science, Cohen increasingly imposed his academic chemistry on the spheres of education and engineering. At the same time he widened his argument from general chemistry to natural science as a whole, thereby also changing the opposition: from pharmacists and traditional chemistry, to classicists and religious leaders. In the representations of university chemistry Cohen increasingly includes the demands of society, while still maintaining a hierarchical distinction between pure science and practice.

At the eve of the outbreak of the world war the optimistic ideals of community, internationalism and progress of the late nineteenth century were already crumbling. For the ‘neutral’ physical chemists in the Netherlands the “chemists’ war” functioned as a catalytic agent: it irreversibly pushed a series of developments in science, society and their interrelation

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[268] Van Deventer (1914a), p.64.
[269] Van Deventer (1887b), p.323.
[270] Van Deventer (1914a).

over an energy barrier. The world around Cohen changed as Dutch education was reformed, the chemical industry grew exponentially and European culture groaned under the pressure of the war-inflicted chaos. In this concluding chapter the Janus-face of purity in Cohen's public science becomes truly manifest.

4.1 Demobilization and pedagogical equality

Above we have seen many ways in which Cohen engaged in debates about educational reforms. As physical chemist he criticized the HBS chemistry education program and the relation of the university to the polytechnic college. In the early 1910's he defended, more as natural scientist than as chemist, the public value of scientific education in distinction to humanistic dominance. The latter distinction was fought out around the concept of "general development" and ultimately amounted to the place of science in Dutch culture. In 1917, the Limburg Law would establish the equality of humanistic and scientific general development. This law provided HBS-students with direct access to the science and medical faculties. Why did this come about precisely during the war years? Cohen's position as Utrecht University's Rector Magnificus in 1915-1916 is a particularly interesting departure point to establish a perspective on the Dutch education system under pressure of international conflict.

The Senate of Utrecht University – the representative governing body that consisted of all the professors – elected yearly a new *Rector Magnificus*. The position of the rector was partly symbolical and partly political. Cohen opened the academic year and attended student promotions, but also maintained contact with student associations, represented the Senate in the board of governors and in the national association of universities, the *Rectorencollege*.[271] The two office calendars of Cohen's year as rector demonstrate direct and indirect impact of the

[271] Board of rectors.

war.[272] Since the German invasion of Belgium, the Netherlands were flooded with Belgian refugees and most Dutch youngsters were mobilized. In a refugee camp in Amersfoort, Utrecht professors had organized lecture series for the Belgian youth. In 1915/1916 this initiative was extended to inviting these Belgian youngsters to Utrecht University. From November 1st a group of fifteen Belgian internees was housed in Utrecht and was allowed entrance to university education. Cohen promised them to make their "forced stay" as "useful and pleasant" as possible.[273] It was an issue of national significance to maintain neutrality while at the same time pleasing the neighboring adversaries. For the official admission of the Belgian students extraordinary agreement was therefore required from the Ministry of War and the Commander-in-Chief. Utrecht University, under the leadership of Cohen, maneuvered between the different sides in the war to maintain its neutrality and later in the year also admitted two German students. The Dutch Universities joined hands with Scandinavian and Swiss institutions to provide "books, information and mediation" to students who were captives of war. The Netherlands focused on Belgian students in England, English students in Germany and German students in England, so that no preference for either side could be discerned.[274]

Besides these initiatives for foreign students, the Utrecht Senate was also worried about the mobilized Dutch students. It was partly motivated by a fear for serious study delay as a result of the mobilization. Not only did it delay (future) students in the literal sense, it would also be of bad influence to the student's morale and desire to complete full study programs at the

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[272] Utrechts Archief [UA], Archive of the Rijksuniversiteit Utrecht, senaat en rector, 292-1, inv.nr. 1.1.2.430-431, Kantooragenda's van de rector, met ingeplakte kranteknipsels en stukken, 1915-1916.
[273] Ibidem, inv.nr.1.1.2.430, Ernst Cohen to Belgian students, 4 October 1915.
[274] Ibidem, inv.nr. 1.1.2.431, "Nederlands Universitair Comité voor Studiehulp aan Krijgsgevangen Studenten" to Rector Magnificus Utrecht University, 16-4-1916.

university.[275] Later, Cohen and the Senate would use this as argument to plead for reforms in higher education. However, the war was first reason for prime minister and minister of domestic affairs, P.W.A. Cort van der Linden, to stall the question of university admission for HBS students. It were "the present circumstances" of the precarious neutrality that took up all his political attention and energy and prohibited current realization of their wishes.[276] Cohen subsequently marked this day, March 3, 1916 as "a black day in the history of Universities".[277] The request for reforms had been uttered by an address movement of HBS directors and high school teachers which received broad support from "men in scientific and technical fields".[278] The address movement knew that the liberal Cort van der Linden approved of their "desires in general".[279] Their task was to convince him of the urgency "in these difficult times", which they attempted in an elaborate reply.[280] Against the backdrop of a destructive world war they stressed the "great urgency" to adjust the "most severe wrong" of the dislodge between HBS and science faculties. They took chemistry as illustrative example where more chemistry students entered the polytechnic college than all universities together. The polytechnic was used as the shortest way to careers in education and industry leading to "underqualified teachers in secondary education" who lacked the general development of a truly academic study. The war was conclusively used

[275] Ibidem, inv.nr. 75, Ingekomen en minuten van uitgaande agenda's 1911-1927, Utrecht Senate to Minister of War and Commander in Chief, 22 November 1915.
[276] Ibidem, inv.nr. 1.1.2.430, 3 maart 1916. Attached: "Adresbeweging ter verkrijging van het promotierecht voor de Hoogere Burgerschool met vijfjarigen cursus".
[277] Ibidem.
[278] The movement was titled "Adresbeweging ter verkrijging van het promotierecht voor de Hoogere Burgerschool met vijfjarigen cursus" (Address movement for the acquisition of promotion right of the Higher Civilian School with 5-year course). The circular was widely supported and in total 4369 declarations of support were attached: 136 professors, 1488 medical doctors, 283 pharmacists, 926 engineers, 1290 teachers and 246 other. Ibidem.
[279] Cort van der Linden was educated in law but also maintained a positivistic hope that the social sciences would eventually discern laws and regularities similar to the natural sciences. Minderaa (1979).
[280] Ibidem.

as argument *in favor* of reform: "…all this in times, when it is urgently needed to make every effort to increase our activity in every area as high as possible after the war!"[281]

As the war intensified many dimensions of life, also the reform movement in education became stronger. In June 1916, the board of governors of Utrecht University joined by offering their support to the Senate. [282] Cohen would promote this way of conduct at all Dutch universities through the board of rectors. The Senate greeted the new support with enthusiasm and stressed in their response how mobilization had "aggravated" the situation, because it made it probable that many aspiring teachers would follow the "shorter route" of private study and central exams instead of academic education.[283] On a national level the address movement gained more substance in the form of the 'KNK' association that pleaded for the legal equality of "*klassieke en niet-klassieke*" (KNK) education.[284] The most important change with the previous movements was the expansion of the scope. Instead of demanding a small alteration within existing structures – connection of HBS to science and medical faculties – the KNK now explicitly focused on *all* faculties and desired a complete reform of the Dutch education system. The main aim of the KNK was more of a principal than of an institutional nature: the intellectual equivalence of natural sciences, modern languages and the classics in the harmonious development of the mind.[285] The composition of the executive board and the list of sympathizers reflected the broader approach. Besides chemist Cohen, physiologist Hamburger and engineer

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[281] Ibidem.
[282] [UA], Archive of the Rijksuniversiteit Utrecht, senaat en rector, 292-1, inv.nr. 1.1.2.48, Ingekomen en minuten van uitgaande stukken 1915/1916, College van Curatoren to the Senaat, 21 juni 1916; [UA], Archive of the Rijksuniversiteit Utrecht, senaat en rector, 292-1, inv.nr. 1.1.1.8, Resoluties en notulen van de senaat 1899 sept. - 1916 sept., Notulen Senaatsvergadering 7 juli 1916.
[283] Ibidem, inv.nr. 1.1.1.48, Senaat to College van Curatoren, 8 juli 1916.
[284] "Vereeniging ter verkrijging van wettelijke gelijkstelling in Nederland en in de Koloniën van klassieke en niet-klassieke opleiding als Voorbereiding tot de studie aan Universiteit en Hoogeschool" (Association for acquiring legal equality in the Netherlands and the Colonies of classic and non-classic education as preparation for study at the University and College). Hamburger (1917).
[285] Hamburger (1917), pp.10-11, 19.

Van Sandick, the 30-member board consisted of politicians, HBS directors and professors and teachers from all disciplines.[286]

Already early in 1917 KNK could present the first result. The president of the association was mr. J. Limburg, a member of the Second chamber for the left-liberal "Vrijzinnig-Democratisch Verbond".[287] He convinced minister of domestic affairs Van der Linden to reconsider his previous rebuttal by emphasizing the way mobilization increased the urgency for the issue.[288] A few months later a bill was promoted in parliament and supported by a member from every party, to grant admission of HBS-pupils to the faculties of science and medicine. For the KNK this 'Limburg Law' was the first "breach in the wall that separates the HBS from the University".[289] Cohen stressed the success of this breach as the bill passed in 1917 "*without deliberation and without voting by call*".[290] It is quite ironic that in the 1920s the mobilization argument turned against the chemists who advocated it. Cohen complained that there were *too many* students at the university after demobilization. Historian of science Eduard-Jan Dijksterhuis pointed the finger back at the chemists. It was their own fault, a direct consequence of the Limburg Law and their "loud-spoken pleas that the 'dead old languages' were not required for their practical field".[291]

4.2 'Prostitution' of science and the future of society

The war intensified the educational debates in the Netherlands and was eventually used as the argument that catalyzed change. The Limburg Law was the legal affirmation of the value of natural scientific education for society through its proper general development. Ultimately, it was

[286] Hamburger (1917), pp.5-8.
[287] 'Liberal-Democratic Union'
[288] Hamburger (1917), pp.12-13.
[289] Ibidem, p.14.
[290] His emphasis. Cohen (1919), p.7.
[291] Dijksterhuis (1924), pp.398-399.

an expression of trust that natural science played an important role in the future of society. The support of many classically trained professors, teachers and politicians might have been crucial in this respect, because it bridged the cultural abyss between the sciences and the humanities. The war made this abyss even more manifest. The use of science and technology in the military effort on both sides was food for critics to appoint the "odium of materialism" to science and oppose it to the humanities' "aureole of delicate civilization and taste".[292] The mobilization of science in the modern war sparked a debate all over Europe about the relation between science, specialization, civilization and cultural fragmentation. Ultimately, this addressed the issue whether science could also provide the moral values for individual lives and society. Famously, Max Weber addressed this issue in his 1917 lecture on "*Wissenschaft als Beruf*" by quoting Lev Tolstoy that science did not answer the only question of importance: "What shall we do and how shall we live?"[293]

One European that did not seem too worried about the impact of the war on scientistic optimism was Ernst Cohen. He had heard the president of the *School voor Wijsbegeerte*, at its opening in Amersfoort, proclaim that "exact science must learn to purify itself from delusion".[294] At the 280th anniversary of Utrecht University its rector Cohen used this as proof that "he had not been fighting windmills" with his older plea for more knowledge of natural science in all strata of society. For him it had been a rhetorical question whether this would benefit the "tolerance and the happiness of the people".[295] In and after the war, Cohen addressed this general issue in public debates where he presented himself foremost as natural scientist in opposition to politics, the humanities and religion. Seemingly neglecting the bold facts of the war, he held on to the

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292 Hamburger (1917), p.20.
293 Weber (1992), p.93.
294 'School for philosophy'. Cohen (1916b), p.20.
295 Cohen (1916a).

pure ideals of his science and maintained that science was the way to a future of happiness, tolerance and civilization for Dutch society.

In 1917 Cohen got the perfect opportunity to present this view on the public stage of a lecture series on the "Future of Society". The 'student association for social lectures' in Amsterdam attempted to escape the "fleeting news of the day" with a focus on this "pre-eminent social problem".[296] Instead of the "unscientific" mystic, religious and "naïve socialist" utopias of the past, the students responded to a growing "self-confidence" amongst scientists to inform society "what we must want".[297] The scientific "predictions", superior to metaphysics and religion, would deal with the "improvement of humanity". Amsterdam sociologist S.R. Steinmetz inspired the student's underlying social Darwinist perspective on human society. The first four lecturers asked how human beings could be improved directly through eugenics, while the last five elicited the ways to improve the surrounding environment through art, morality and science.[298] The focus on the future was a failed attempt to leave the war out of the picture. Almost all of the speakers referred to the war, either as evidence of their point or as situation that aggravated their issue. All admitted in one way or another that this "most purposeless of all wars" killed the late nineteenth century utopias of internationalism and community spirit.[299] But most also identified a "will to intervene", a new "lust for creation" and the demand for "a general contemplation of reality".[300] The lecture series portrayed a future of action and reflection: change had to be accomplished in concrete steps and civilization was to be safeguarded by a synthetic understanding of reality.

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[296] Lotsy et al. (1917), p.v.
[297] Ibidem, pp.viii, xiii, xv.
[298] Ibidem, pp.xv-xvi.
[299] Uttered by Prof. Dr. Julius Wolf. Ibidem, p.182.
[300] Uttered respectively by law student M.P.de Vrij and engineer I.P.de Vooys, Ibidem, pp.xxi-xxiii, 187.

Cohen concluded the series with his lecture “Quo Vadimus: a view on the future of science”.[301] He disregarded all the questions of the students: faith and trust in science were not decreasing, science had never deceived people, science was still progressing and the public was finally – after ages of religious and humanistic dominance – turning towards science.[302] His scientistic optimism made him react “astonished” to the question whether the World War had made people turn to mysticism instead. The “adepts of the goddess”, pure science, nor the “practitioners”, had anything to do with the “feuds between inflamed nations”. Science was “prostituted” in the war for “disasters and destruction”, while in principle it served the happiness and prosperity of the people.[303] Cohen portrayed the involvement of scientists and the military application of scientific and technological findings in the war as a political problem. At the end of his lecture he even quoted Bismarck and Cuvier to present the natural scientist in general, the chemist in particular, as most well-equipped for making wartime decisions. Only with more knowledge of the natural sciences politicians could judge “clearly about the power of science”.[304] That is to say, the scientific and technological understanding that led to the production of bombs and poison gas, also equipped the scientist morally to make just decisions. With this rhetorical strategy he only associated the positive consequences with the nature of science, while he excluded the negative, unintended consequences from the responsibility of science. Ultimately the rhetorical separation between the intrinsically good science and morally dangerous politics served the goal of protecting the professional autonomy of science.[305]

[301] ‘Where do we go?’ Cohen (1917a).
[302] Ibidem, pp.307-315.
[303] Ibidem, pp.308-309.
[304] Ibidem, pp.320-321.
[305] Gieryn (1983), pp.789-791.

H.J. Prins questioned these rhetorical strategies of Cohen. After publication of Cohen's lecture in the daily journal *Algemeen Handelsblad* and the *Chemische Weekblad*, the chemical engineer Prins from Zaandam reacted sarcastically. He quoted Goethe to mirror the professor's opening in which Cohen had used two quotes of the German poet that sketched an image of a peaceful home in which a war, taking place somewhere far away, was being discussed.[306] This relates metaphorically to his plea in favor of a pure science that remains isolated from the 'feuds'. Engineer Prins precisely criticized this 'pure isolation' as a disconnection of science from life and reality: "*Wissenschaften entfernen sich im Ganzen / immer von Leben und kehren nur durch / einen Umweg wieder dahin zurüc*k".[307] Prins also ridiculed the great civilizing influence that Cohen sketched of science: just think about Germany who claimed to be on top of natural scientific developments and "how the humane in man" had been expressed there. Most probably he had the "Manifesto of 93 intellectuals" in mind. This piece of war propaganda was signed by many prominent scientists and scholars from Germany, in which 'war lies' about the invasion of Belgium were being denied. It is impossible that this passed Cohen's attention. Not only because it caused widespread public upheaval, but above all because he received a copy directly from Fritz Haber, who asked him to help "spread the truth in the neutral countries".[308] Although Cohen never followed up on this request, he also never denounced the manifesto. It stood in direct contrast with Cohen's representations of science, in which it was in principal, and exclusively, to the benefit of mankind and society.

[306] Cohen adapted the following quote from Goethe's *Faust*: "ANDRER BÜRGER: Nichts Bessers weiß ich mir an Sonn- und Feiertagen/Als ein Gespräch von Krieg und Kriegsgeschrei,/Wenn hinten, weit, in der Türkei,/Die Völker aufeinander schlagen./Man steht am Fenster, trinkt sein Gläschen aus/Und sieht den Fluß hinab die bunten Schiffe gleiten;/Dann kehrt man abends froh nach Haus,/Und segnet Fried und Friedenszeiten. DRITTER BÜRGER: Herr Nachbar, ja! so laß ich's auch geschehn:/Sie mögen sich die Köpfe spalten,/Mag alles durcheinander gehn;/Doch nur zu Hause bleib's beim alten." Cohen (1917a), p.299.
[307] 'Science distances itself completely/always from life and returns/with a detour back to it'. Prins (1917), p.529:
[308] [BAL], inv.nr. a38-a41, Fritz Haber to Ernst Cohen, September 23, 1914.

It is this image of science that Cohen would always preserve. He was convinced that everyone shared the expectation that further scientific research would result in “deeper insight in the phenomena of nature” and “new improvements in their existence”.[309] The general progress Cohen expected from science was a meager version of the harmonic unity the other speakers had said to strive for. Ironically, he expressed the intellectual progress established by science in purely material, technological terms. Many other authors, instead, identified degradation and fragmentation as a consequence of specialization. What was really “worrying”, according to Cohen, was rather the inclusion of philosophy in the early study years at the university: the student was not yet “*resistenzfähig*” and ran the danger of going down the path of mysticism.[310] Cohen considered the history of science an “antidote” to these philosophical urges and vanity.[311] That Cohen was idiosyncratic in his scientism, becomes clear in comparison with Van Deventer. He regarded the history of science in direct relation to the “desire for more philosophy”, that had to counter the specializing sciences and fragmenting society.[312] As rector, Cohen had even recommended further specialization in medicine and the sciences, while demanding a “widening of the perspective” for law, theology, philology and history by including more natural scientific principles in their education.[313]

Prins, in his critical response, attacked specialization as a degradation of the scientific method, whose results could only be “learnedness”, expert knowledge and utility. Instead he defended “the harmonic development of all human gifts…inner and outer intellectual relations,

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[309] Cohen (1917a), p.307.
[310] Ibidem, p.315.
[311] Cohen (1917a).
[312] Van Deventer (1914a).
[313] Cohen (1916a), pp.182-183.

in harmony with one self and his surroundings".[314] The "one-sidedness" of specialization ultimately led to the "utilitarian prostitution" of science that made the "real natural scientific man an ashamed spectator".[315] In Prins' opinion also the negative consequences of the specializing sciences belonged to its responsibility. He considered Cohen's observation "remarkable" of the "ill-fated specialization" only at the other side, with philosophy. To Prins, philosophy was at the core of real science in the form of the logic of reasoning and argument. The only way out of the fragmentation in society, caused by specialization, was this general perspective offered by philosophy and logic. Cohen's unmotivated denial of the synthetic perspective of philosophy was a manifestation of the "abyss between humanistic philosophy and utilistic natural scientificity".[316] Hopefully, ended Prins sarcastically, would the student who had experienced proper natural scientific education ask about the "causal relation between philosophy and aberrations".[317]

In a way, Cohen responded to this last remark at the opening of the 1921 "National Congress for Natural Science and Medicine". This congress embodied the progress and cultural self-confidence of Dutch science, as well as its increasing fragmentation through specialization.[318] Still, the general opening lecture was a "forum for images of science".[319] Cohen, who organized the Congress, opened before a generally educated audience of "birds of different feathers" with a lecture titled "Photography or Caricature".[320] He decided to attack, not for the first time, the well-known "bankruptcy of science" argument of the French writer and historian Ferdinand Brunetière: science did not, and would never be able to, answer the three "cardinal questions:

[314] Prins (1917), p.532.
[315] Ibidem, p.533.
[316] Ibidem.
[317] Ibidem, p.534.
[318] Mijnhardt (2004), pp.25-26; Theunissen (1994), p.141; Visser (1991), pp.37, 40, 46.
[319] Maas (2001a), p.82.
[320] Cohen (1921a), pp.2-3.

from where do we come, who are we and where are we going?”.[321] Brunetière attacked positivist claims by natural scientists that science would replace religion completely in deciding on what human reality was. He fulminated the materialist attachment to earthly life that was a consequence of science and deeply “irrational for a being that has to die”.[322] Although the original text was published in 1895 there had been little Dutch attention for it initially, and it was the war that had really fueled the debate in the Netherlands. Weber’s famous words also played a role in setting the debate about science and values central again in Europe. Previously Brunetière figured in Cohen’s rhetorical repertoire as representative of humanistic vanity in the context of the educational debates. Here, he claimed to attack above all Dutch “superficial readings” of Brunetière that offered “caricatures” of science. As example, Cohen remarked that few had noted that Brunetière opposed religion to both science and the humanities, who both failed to give “guidance” in life.[323]

Cohen attacked most prominently the “scientifically trained” E. Reinders. This biology teacher at the *Nederlandsch Lyceum* published a series of articles in the “democratic journal” *De Opbouw* on the ‘bankruptcy’ of Darwinism and natural science.[324] The question is whether Reinders was the only one offering caricatures, because his articles were not as anti-science as Cohen presented them. Reinders explicitly attacked the “philosophical Darwinism” of Haeckel that offered the naïve promise of an ethical-philosophical system based on natural science.[325] In the later articles Reinders observed a changing, more skeptical attitude towards natural

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[321] Cohen (1916a), pp.171-174; Cohen (1917a), p.315; Cohen (1921a), p.5.
[322] Cohen (1921a), p.5.
[323] Cohen (1921a), p.6.
[324] At this ‘lyceum’ the decision between HBS or gymnasium was postponed for one or two years. Reinders would later become botany professor in Wageningen. Moor (1996), p.23. The journal *De Opbouw* (‘The Build-up’) was published between 1918 and 1940. Reinders (1918; 1919; 1920).
[325] Reinders (1918), pp.463-464.

science.[326] This attitude originated not in any bankruptcy of natural science, but rather in the failing public rhetoric of scientists. They misused their authority, obtained in their specialized domains of science, to initiate ideas in people of the unattainable expectation of “world peace and human happiness” from science. Also, they degraded everybody who believed science popularizers or criticasters (like Brunetière and Haeckel) from a fear “that their authority would be shaken in broader circles”.[327] Without an explicit reference he related his argument to Cohen, “one of our most competent natural investigators”, who demanded more knowledge of science in all domains of society. In a leap of abstraction, Reinders understood these cultural debates as a perennial philosophical strive in humanity between rationalism and intuition. The problem was that although intellectuals were able to alternate between the two poles, the “cultural crowd” was exposed to the danger of being “annexed by one of the intellectual antipodes”. The HBS, in his opinion, had laid too much emphasis on the rational, on science, and overemphasized its “certainty”. To address the “spirit of times”, which was not univocally rational-scientific anymore, he demanded “personal reflection” of the teachers and corresponding educational reforms.[328]

Cohen took offence at this last point and wanted to discuss it at the Congress were so many “teachers of the teachers” were present.[329] He misrepresented Reinders when he ascribed to him the opinion that the bankruptcy of science was “an accomplished fact” and that the “design and methods” of the HBS caused this. This caricature of Reinders was for Cohen reason to stress the “direct and indirect” impact of science on society through industry, technology and popularization. Avoiding the condemned rhetoric he “refrained from carrying coal to Newcastle”

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[326] Reinders (1919), p.207; Reinders, (1920), p.899.
[327] Ibidem, pp.906-907.
[328] Ibidem, p.915.
[329] Cohen (1921a), p.7.

and instead self-evidently passed over the ‘direct impact’. In a self-proclaimed “aphoristic” history of science popularization, he demarcated the real, modest science from the popularized, “overconfident” pseudoscience: attempts of non-experts at the construction of natural scientific worldviews were a “danger” for a lay audience.[330] Oddly enough, Cohen concluded with a natural scientific worldview. He presented a biographical image of the personal development achieved by natural science: the natural scientist fostered no religious ideas, led his life by “*Wahrhaftigkeit und Gewissenhaftigkeit*” and excelled in perseverance, self-control, fairness, prudence, modesty and altruism.[331] The moral success of his natural scientific persona followed from the “appreciation, friendship, love” he received and the “complete resignation” that he found in natural science when his beloved wife passed away. He answered Reinders, conclusively, with a clear “No”: the teachers of the teachers did not have to reflect on their educational methods because it had not been them who “prostituted” science. What they should do, instead, was communicate that natural science could be a guidance in a life of “satisfaction and happiness”.[332] Cohen almost exactly mirrored the rhetoric Reinders attacked him for. He presented this natural scientific guidance in life to demarcate his science from the “over-confident” popularized science of Haeckel and the conservative religious solution of Brunetière. As such, Cohen provided a rational-scientific answer to the “spirit of the times”.

In the years between 1917 and 1921, Cohen rhetorically engineered an image of science that obscured the impact of and on the war. He neglected the “odium of materialism” and instead stressed the civilizing value of science by comparison to the humanities and in clear demarcation from politics and religion. Again the war appeared more an opportunity than an obstacle for

[330] Ibidem, pp.9-11.
[331] ‘Veracity and conscientiousness’. Ibidem, pp.15-16.
[332] Ibidem, p.16.

Cohen, as he took another step towards a scientistic perspective on life and society. The biographical image of natural science was a moral framework that challenged religion, and he only considered well-trained scientists capable of political decisions that concerned scientific knowledge or applications. While his views progressed, the audiences also became broader: the students in Amsterdam and the Congress of 1921 ensured that his cultural range grew. As Cohen furthered his purely scientific perspective on society, it were precisely two men of practice, the high school teacher Reinders and the engineer Prins, who reprimanded him in professional and cultural journals. They criticized the academic detachment from life that separated ‘pure’ science from its negative consequences and the inflated rhetoric that promised peace and happiness. The future of society they projected in response was one of harmonious development of the mind. This included philosophy to counter the specialization of the sciences which had caused their utilitarian prostitution during the war. Cohen appeared deaf to such remarks, but not simply held on to nineteenth century positivist ideals either. Rather he shaped his arguments for and representations of natural sciences continuously to accommodate it to the spirit of the times.

4.3 Industrial progress and chemical reforms

Above we have seen how Cohen’s answer to the problems of the times moved further away from other cultural domains, as he eventually ascribed to natural science the role of guidance in life. It is telling that Cohen was opposed in this debate about the civilizing value of science by an engineer. As Prins questioned the moral primacy of science, compared to philosophy and religion, he also opposed practical to pure chemistry. The conflict between a persistent ‘pure’ chemist and a self-confident engineer has to be understood in the context of a changing Dutch chemical community. The *Nederlandsche Chemische Vereeniging* was established with the noble aim of unifying science and industry but an “intellectual and social gulf” increasingly separated the worlds of academically trained and middle-rank chemists.[333] In the war years the existing oppositions were emphasized. The precarious political neutrality made the Netherlands comply with the Allied trade blockade of Germany. German chemical industry was absolutely leading at the time, and many countries depended on it especially for more sophisticated chemical products.[334] The blockade consequentially caused great shortages, at first, but also the opportunity for national industries to flourish in isolation.

The great expansion of Dutch chemical industry put pressure on the relation between science, technology and industry both in rhetoric and practice. Symbolic is the appointment in 1916 of dr. A. Lam, the director of the Nutrition Inspection Department in Rotterdam, as president of the Dutch chemical society.[335] Cohen had just served his second period as president in which he attempted to ignore engineers for the benefit of university education.[336] Lam was the first chemist with a practical position to preside the society. It reflected the relative increase of the amount of chemical engineers in the Netherlands, which would continue to rise until 1923.[337] Also in 1916, the yearly general meeting was for the first time split up into two “sections” of “general chemistry” and “applied chemistry”.[338] Every meeting would still open with the “uniting force” of one “pure exposition”. In the section meetings more detailed laboratory reports could be communicated to a circle of specialized colleagues, because “exchange of ideas is only fruitful and reviving between experts in the narrow sense”.[339] This “specialization” was the manifestation of the gap between the chemistry practiced in and outside of universities.

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[333] Homburg (2008), p.206.
[334] The same occurred in the United States. Servos (1990), p.208.
[335] By 1928 the effects of the Limburg Law equalized the relative shares of academically trained and technical chemists again. Snelders (1997), p.221.
[336] See above, section 3.1.2. Cohen (1913).
[337] Snelders (1997), pp.33-34.
[338] *Chemisch Weekblad*, 13(20), pp.516-513, esp.516.
[339] Ibidem.

A similar concern led to a reform in the journal of the society, the *Chemisch Weekblad*. However, the initial initiative for reforming the journal knew a scientific motive with a national coloring. Professor A. Smits, the successor of Bakhuis Roozeboom in Amsterdam, proposed in 1916 the introduction of a “scientific supplement for general and inorganic chemistry”.[340] It would unite the results of Dutch chemists in these fields and make them, by translation in foreign languages, readable to the world. Technical chemist A. Korevaar reacted that the world did not need “one more journal” and instead proposed a “translation bureau” to achieve the same goal.[341] Cohen agreed with Korevaar that another journal would be “a failure”. However, his international orientation in the world of physical chemistry made him discard a national translation bureau. Instead he pointed at the pre-war proposal of the *Association internationale des sociétés chimiques*, of which he was a member, to institute an international translation office.[342] In the context of the war, Korevaar and Smits aimed at establishing national institutions to ensure connection to international science, while Cohen maintained his trust in the international organization of the science regardless of the separations caused by the war.

Against fragmentation and in favor of economy, several members proposed instead to combine the projected supplement with the existing journal *Receuil des Travaux Chimiques des Pays-Bas*.[343] This journal was established in 1882 by organic chemists from Leiden which had separated them from the physical chemistry of Amsterdam. The separation between physical and organic chemists was later reproduced in the chemical society, where organic chemistry was

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[340] *Chemisch Weekblad*, 13(52), pp.1349-1350.
[341] Korevaar (1917).
[342] Cohen (1917d).
[343] ‘Algemeene vergadering Nederlandsche Chemische Vereniging’, *Chemisch Weekblad*, 14(30), 1917, pp.682-691, esp pp.686-687.

underrepresented.[344] Funds for this fusion would only become available by 1919, when the NCV could benefit from the progress in Dutch chemical industry. By then, the main argument was that the *Chemisch Weekblad* was not really a proper scientific journal, nor a "technical-economic organ". More than *adding* a scientific supplement, the reform aimed at a "separation" of the two sections.[345] At the general meeting of the society in Maastricht in 1919, president Hugo Kruyt presented the new plans. The *Chemisch Weekblad* would focus on technical and economic news, while the supplement of the *Recueil* was the place for scientific communications. Both were published in much bigger formats. This luxurious improvement was made possible by the promised support for the coming six years of four industrial companies.[346] Financed by industry, the gulf between practice and university took a paper shape.

The ties between industry and the society were further strengthened through the cooperation between the *Vereniging van de Nederlandsche Chemische Industrie* (VNCI) and the NCV.[347] The institution of the VNCI was the consequence of a request by the new national trade fair, the *Jaarbeurs*, in 1917 to several pharmaceutical and chemical factories for participation in the nationwide display of the products and progress of Dutch industries.[348] About 30 industrial representatives established the society for the practical reason of reserving space at the trade fair, and in light of the idea that "cooperation between chemical and pharmaceutical industrial partners" was desired. Both the *Jaarbeurs* and the VNCI could arise because of the necessary

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[344] Homburg (2008), pp.193, 207.
[345] *Chemisch Weekblad*, 16(27), 1919, pp.917-919.
[346] 'Verslag van de Algemeene Vergadering te Maastricht der Nederlandsche Chemische Vereeniging'. *Chemisch Weekblad*, 16(31), 1919, pp.1083-1086.
[347] Society of Dutch Chemical Industry. Each society had one board membership in the other society. Kruyt (1918).
[348] Strengers (1918).

break in German dependency and were the manifestation of “progress of chemical-industrial activity”.[349]

Lam’s assignment was the first sign of the changing relations in the chemical community. Under his successor Kruyt these changes manifested themselves rhetorically and in concrete reforms. Although Kruyt was a university professor his presidency was a clear break with the academic domination of the past.[350] In Cohen’s rector year, 1915-1916, Kruyt became extraordinary professor (without salary raise) and moved in to the newly build second floor of the Van ‘t Hoff laboratory. Cohen and Kruyt would work physically close to each other, but the differences in their scientific subjects and social interests were vast. Where Cohen symbolized the society’s failed ambition and academic focus of the first hour, Kruyt appeared to act in the spirit of the times. Characteristic in that respect was the “new direction” he took with the society, by relocating the yearly meetings from the traditional academic centers to rural industry towns like Deventer and Maastricht.[351] He opened the 2-day meeting with a lecture on the “cooperation between science and industry” to emphasize that the “accidental” industrial growth during the war had to be “consolidated” by the appointment of scientifically trained young chemists in the industrial sector.[352] The scientific education at the universities had therefore to include practically oriented training, and “trust” had to be established between industry and academy who shared interests and had to improve their relations.[353] Ultimately, they had to share the idea (and realize in practice) that “pure science [is] an indispensable condition” for industrial

[349] Kruyt (1918a), p.419.
[350] Somsen (1998a), pp.180-182.
[351] *Chemisch Weekblad*, 15(16), 1918; *Chemisch Weekblad*, 16(31), 1919, pp.1083-1086.
[352] Kruyt (1918a),p.420.
[353] Ibidem, pp.420-423.

development.[354] These views were widely shared in the society, as similar ambitions were uttered by industrialists, engineers and professors from the polytechnic college.[355] Although Kruyt presented a similar linear image of the science-industry relation as Cohen did at times, he differed in the practical consequences attached to the rhetoric. The separations between the chemists at the university and in practice became more manifest in public rhetoric, the meetings and the journal. At the same time, it enabled more explicit cooperation between the different spheres as they became better defined. Under the motto that "a healthy, flourishing scientific life also benefits industry" Kruyt was able to secure substantial financial support from chemical industry in 1918.[356]

4.4 Cohen in a changing world

In the context of the Dutch chemical society Cohen symbolized the autonomy and arrogance of academic chemistry. How did he adapt to the changing world around him, in which engineers obtained a stronger voice, HBS students could enter university and the progressivist ideals of the first decades of the twentieth century were shattered by the war? Compared to the years before the war, Cohen became less active in the circles of secondary education, engineering and the chemical society. In the 1920s he reoriented his activities outside of his laboratory especially beyond the national borders. It was in this semi-public role that the content of his science, the cultural sense of purity, his scientistic optimism and his character self-evidently combined. First I show, in a short overview, how Cohen portrayed the future of science and society, how he

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[354] Ibidem, p.425.

[355] In the case of Prins it really amounted to ambitions, as much had to change in Dutch academic research and education before such harmony would be really possible. Prins (1918), p.1664; Prins (1919), p.37. Hasselt et al. (1918), pp.742-742.

[356] With the assistance of prominent industrialist F.G. Waller, the director of the *Nederlandsche Gist- en Spiritusfabriek*, 22.250,- guilders were raised from amongst others *Philips*, *Calvé*, several candle factories and the *Bataafsche petroleummaatschappij* (Shell). Algemeene vergadering Nederlandsche Chemische Vereeniging 13-7-1918', *Chemisch Weekblad*, 15(29), pp.916-925, esp.p.917.

partly failed to alter his own relations to the world of practice and how he remained bitter about the Dutch appreciation for science.

In his ‘future of society’ lecture in 1917 Cohen sketched a view on the future of the relations between science and society. Academies of Science, government research laboratories and international associations of scientific societies were the three pillars that would increase the activity and impact of science.[357] The academy of science, consisting of “pure” and “applied” scientists, had to interfere in the daily life of civilians. The fire brigade served as the main example that would raise both social interest and financial support for science by its promised improvements in security. Government laboratories would be of great “use to national welfare”, just like the laboratories in London, Berlin, Washington had proved. In his view on the future of science and society, pure and applied science joined hands in practically orientated academies of science and government laboratories, so that the amount of public funding reflected the awareness that science provided security, national welfare and practical results. In 1917, the Dutch government and the Academy of Science would actually install the ‘Scientific Commission of Advice and Research in the interest of Welfare and Defense’ that had to fulfill a function similar to the foreign scientific institutions that applied science for war and defense purposes. Overall, this Dutch initiative would resort little effect, and also the subcommittee for metals of which Cohen was a member, did not manage to raise the interest of practice: the diamond industry did not respond to their offer to help out with the phosphor bronze shortages in diamond cutting.[358]

[357] Cohen (1917a), pp.315-316.
[358] ‘Mededeelingen betreffende de Wetenschappelijke Commissie van Advies en Onderzoek in het belang van Volkswelvaart en Weerbaarheid. No.4.’, F. van Rossen, pp.13-14.

In 1921, Cohen again used diamonds in an attempt to connect his pure science to practice. Before the audience of the Royal Institute of Engineers Cohen presented on the "metastability of matter and the diamond problem" as a continuation of his earlier metal disease speeches.[359] Now he had already extended his research into the organic world, and he deemed it of "the greatest importance" to "the method of diamond production" to know more about the metastable states of carbon. But this research required some advanced instruments that the chemist did not yet have in his lab. That the world around Cohen had changed becomes evidently clear when he asks, for the first time, directly for funding. If "the industry" was "at all willing to render assistance in this issue", Cohen would be "very willing" to do the research.[360] The reaction to this request by engineer E.B. Wolff – who we already met above – is indicative of the increased self-confidence of the practical world: "For us it is always extremely interesting to hear the clear communications of prof. Cohen about the investigations performed by him and his colleagues, but what I did not understand is, why he asks financial support for specifically the diamond problem that, as we have heard, is currently still a pure scientific research?"[361] Instead of pure science, he argued that much more funding had to be allocated to "technical-scientific" research. In Cohen's reply the previously communicated clear-cut image of a tree with fruits had completely disappeared: "why should we make such a sharp distinction between technic-scientific and pure scientific research? Isn't it ultimately all *"één pot nat"*, tarred with the same brush?"[362] Cohen was well aware of the changed climate as far as it could benefit his science: industry had money, why would it not fund pure science irrespective of any direct potential of application? Ultimately, he had not let go of his strict hierarchical separation between science

359 Cohen (1921a).
360 Ibidem, p.181.
361 Ibidem, p.183.
362 Ibidem.

and engineering. But by 1921 engineers did not simply accept such a scientific sense of supremacy and reacted accordingly.

A thread running through Cohen's relation to society is the supposed lack of appreciation for science. Van 't Hoff's departure from Amsterdam and from life were both occasions for Cohen to emphasize this wrong. In 1923 this pessimistic rhetoric about Dutch culture translated into public action: Cohen openly refused the Companion of the order of Orange Nassau.[363] His defense of this decision received much attention in the daily newspapers.[364] In one newspaper, the NRC, Cohen published his defense titled "Pious wishes?". His main point was that the decoration did not make a distinction between the "man of science" and the "public servant" in the person of the professor. A new official decoration is required to exclusively praise science – to the benefit of the government, the nation and science.[365] This is an explicit attempt by Cohen to allocate to science more public appreciation by giving it a special place in the system of decorations, which also has to distinguish it clearly from 'mere' public servants. The many negative responses he received seem to point out that his ideals of science in society were definitely outdated. Historian and colleague from Utrecht G.W. Kernkamp for example responded cynically to this scientific pretension in his weekly column in *De Amsterdammer*. Cohen had compared his desired "revolution" to Michael Faraday who refused to be raised to nobility. Kernkamp concluded sarcastically that also Cohen "desired nothing else than to remain the simple Ernst Cohen".[366]

[363] Cohen (1923).
[364] Amongst many others: *Het Vaderland*, 26 September, 11 October 1923; *Het Centrum*, 27 September, 11 October, 1923. A caricature appeared by the hand of Ton van Tas in the *Haagsche Post*, 20 October 1923. Sarcastic poems appeared as well, for example 'De Leeuwendoders' (the lion killers). [BAL], inv.nr.a96, Manuscript Autobiography E. Cohen; pp.283-297.
[365] Cohen (1923).
[366] Kernkamp (1923).

Cohen failed in raising funds and interest for his science, but was quite successful when it concerned the national and international organization of science. As president of the National Congress for Natural Science and medicine, in 1921, he displayed his modern persona as 'man of the deed'. He walked into the meeting of a coal trading company and walked out with a thick cheque.[367] And, when he organized an international 'reunion' of chemists from the former belligerent nations in 1922, he was again able to raise the support of industry and government.[368] In the previous chapters I have focused on Cohen's activity outside of his laboratory, but mainly in the Netherlands. His education in Van 't Hoff's Amsterdam laboratory set him from the beginning of his career in close contact with the international world of chemistry. From 1909 onwards Cohen also became active in the international organization of chemistry, in the *Association internationale des sociétés chimiques* and in particular in the committee for the annual tables of physical and chemical constants. The world war broke up the rising international chemical community, but also paved the way for a prominent position of Cohen in this world. Although it is outside of the direct scope of this thesis, the image of purity and public engagement sketched here does shed new light on my previous discussion of Cohen's internationalism.[369] Cohen the international mediator, organizer of the 'International Chemical Reunion Utrecht' and president of the IUPAC is the ideal combination between his science, sense of purity and desire for cultural appreciation. I call interbellum international science a semi-public sphere because although it was a community of mainly academic chemists, the internationalist endeavors received some cultural appreciation and also interested government

[367] The cheque was worth 5000 guilders which amounts today to about 36.000€. Dorsman (2014).
[368] Which industrial companies supported this event is not completely certain. A well-informed guess points to the candle factory Gouda and F.G. Waller. Smit (2014b).
[369] Smit (2014b).

and trade.[370] In the IUPAC Cohen could keep advancing ‘purity’. In the international agreement upon constants, he could defend the importance of metastability. And, international science was for him the pure answer to the impure ‘political’ separations caused by the war. He used the Dutch political neutrality to justify his mediating role, which self-evidently connected to his scientific ideals of purity and objectivity. But, Cohen remained Cohen, purity still implied exclusion, and the Dutch neutrality had never been complete. Thus Cohen kept the universalist ideal of science rhetorically as high as possible, also when chemists openly applied their knowledge to destructive purposes, or when politics established normalization of the international situation before science.

5. Conclusion: Purity in an Impure World

In 1929 Cohen presented himself, before an audience of American industrial chemists, as “a physical chemist in search for purity in an impure world”.[371] This self-presentation made it to the title of this study because it captures his general chemistry as a science as well as his public involvement and situates this in the European culture of the early twentieth century. I followed the chemist Cohen as he proceeded outside of the controlled environment of the Van ‘t Hoff laboratory. Purity was central as scientific concept in the investigations into the metastability of matter, the allotropes of tin and the obsession with the impure values of physical and chemical constants and standard elements. Purity informed the choice of physiological applications – toxicity and hygiene – the metaphorical names of metal ‘diseases’ and his expert analyses in court. Purity distinguished the modest natural scientific education from the vanity of the

[370] For example, the Dutch delegation usually consisted not only of scientists but also of officials of industrial and patent organizations.
[371] Cohen (1929).

humanities, academic from technical chemistry, and science from religion, politics and philosophy. Purity defined natural science as an indispensable element of Dutch culture at the turn of the century and was the foundation on which Cohen build his Van ‘t Hoff laboratory. But, purity has a ‘Janus face’ as it produces impurity, excludes the ‘Other’, and isolates the pure order from the ‘impure world’. Purity motivated Cohen to impose general chemical principles on the spheres of education, industry and culture. Purity excluded engineers, philosophy and pharmacists. Ultimately, purity blinded Cohen for practical interests, negative consequences and the reality of the war.

Between, roughly, 1895 and 1925 Cohen went public in the spheres of education, technology and culture. In educational debates Cohen progressively widened his scope from physical chemistry in 1905 to the entire Dutch education system in 1919. The pedagogical representation of general chemistry and natural science substantiated Cohen’s pleas. First he related the epistemological structure of his science to didactic power before audiences of chemists and high school teachers. He represented general chemistry as deductive, exact and theoretical to associate it with the highly regarded character traits of logical and abstract thinking. He emphasized the rationality of “general principles” in distinction to the factual knowledge of older descriptive chemistry. General chemistry activated not the outmoded memory, but the modern mind. Beyond a mere knowing, this also lead to skill, a deeper insight in the coherence of natural phenomena and an improved esthetic sense. Last but not least, general chemistry related to two utilitarian values or motivations: it simplified education – it improved efficiency – and sparked pleasure. This elaborate exposition of the didactic value of the epistemological structure of his modern science related to a later representation of general chemistry as the provider of general development. In a defense of natural science as a whole Cohen used the laboratory as spatial representation of the value natural scientific education had to society. Before an audience of high school teachers he opposed this in particular to the dominance of the humanities in education and society and their authority claim to the domain of general development. At the establishment of his Van ‘t Hoff laboratory he had already presented it as an emblem of modernity – simple, efficient and modest – and in opposition to the decadent architecture of nineteenth century Dutch culture. In the educational debates he used the laboratory as vehicle to represent scientific education as the modern, social and democratic general development required in the twentieth century. The lab was the “flux of the world”, in harmony with the practical needs of society and in explicit distinction to the all too theoretical writing table of the humanist. The lab shaped the character of the youth according to the rational, practical and modest values of natural science. The friction of opinions in the lab served as model for the public realm of a democratic society.

With respect to the world of professional practice, the balance tilts from engineers and doctors requesting physical chemical knowledge around 1900 to the blatant refusal of pure science by practice after the war. In between, Cohen’s communications to the Dutch engineers became increasingly detached from the experience and interests of the world of application. Central to Cohen’s technological representation of science, and its relations to practice, is Tyndall’s tree metaphor that depicts engineering, industry and life sciences as applied science. Implicitly, this image legitimates pure science by relating it causally to all practical uses. For the medical audience, the methods and principles of general chemistry were represented as a “field of harvest” which would bear fruits that could potentially enlighten the obscure problems of life. Also in the meetings of the chemical society Cohen reproduced the image that industry relied linearly on the education and research of the universities. Towards engineers he explicitly used the tree metaphor to justify his renewed presence as pure chemist. The medical representation of general chemistry, the metal diseases most importantly, made engineering subordinate to pure science, which it staged as curer. Through the years Cohen used another, less hierarchical, representation of science and practice in which they were intimately related and the distinction between theory and practice was superseded. In this image, academic chemistry opens up and adapts itself to practical and societal needs for the benefit of national prosperity. But at different occasions Cohen could not hide his presupposed hierarchy between pure science and the impure world. In competition for students with the polytechnic school, he presented the university as preparation for careers in pure research and practice. The respective metaphors of science as goddess and as cow clearly show a moral hierarchy. And when Cohen requested practical experiences with metal diseases his inclusive representation of science and engineering crumbled as he haughtily discarded the comments of the engineers. In the discussions at the institute of engineers, as well as in court, it became clear that the pure scientist Cohen relied on scientific concepts of utility, reliability and certainty that were irrelevant to practice. His inability to admit this discrepancy between his results and the practical implications fueled the inflated rhetoric of his representation of the relation between pure science and practice. This ultimately imploded at the meeting of engineers in 1921, who by then attained a stronger voice and self-confidence, when Cohen desperately cried out that it was all *"één pot nat"*.

With respect to the place of science in culture, Cohen remained remarkably constant: Dutch society structurally underappreciated natural science, from Van 't Hoff's departure in 1896 to Cohen's denial of Companion of the order of Orange Nassau in 1924. Nothing, not even the First World War, changed his view on the enlightening value of natural science in culture, and the moral superiority of the natural scientific character. Instead, Cohen's scientistic cultural representation of pure science became especially manifest in and after the war. He sketched a biographical image of natural science as a moral guidance in life, in which values like perseverance, prudence, altruism and veracity were leading and would result in happiness and satisfaction. This explicitly challenged religion and philosophy as the providers of moral frameworks for the individual and society, and was a scientistic answer to the issues raised by Weber and Brunetière about the role of science in society. For long also Van Deventer communicated an image of enlightenment to cultural audiences. Instead of dogmatic religion, natural science represented rationality, causality and social progress. Van 't Hoff as a contemporary Socrates was the ultimate symbol of a 'pure', exceptional and artistic Dutch scientist who fought darkness to achieve moral and social enlightenment. But by 1914 he admitted that this enlightening dream was over, and that science was increasingly becoming a useful profession instead. Engineer H.J. Prins elaborated this utilitarian representation of pure science to emphasize its disconnect from practice, its inhumane public appeals and its responsibility for its negative consequences. Cohen's scientific "purity" increasingly detached him from the worlds of education, engineering and culture in general. It lead him to the categorical denial of any association between science and its involvement in war and politics. Also, it structured his response to the dilemmas of modernity and the demand for cultural synthesis: an implicit, but strong scientism. This pessimistic reading of "purity in an impure world" is my response to the historiographical optimism that characterizes this period.

This chronological biographical image of the public science of one physical chemist cuts perpendicularly through the thematic study on the public role of scientists by Baneke.[372] It is above all Cohen's idiosyncratic ideal of pure science that is described in this thesis. The occasional comparison with Van Deventer and the many critical reactions show that it was not

[372] Baneke (2014).

simply a Dutch, a natural scientific or even a physical chemical concept of purity. Still, it provides a useful historical image of a scientistic response to a culture in need of synthesis. Within the content, methods and values of general chemistry, and natural science in general, Cohen found the esthetic, moral and epistemological principles to survive in a rapidly modernizing society. It also shows that the First World War had a significant impact on the relations between academic natural science, secondary education, industry and society at large. Many existing tensions obtained a concrete shape which put the rhetoric of pure science under practical pressure.

Several comparative axes could increase the value of this narrow perspective. First of all, this case could be compared to the self-perception of physical chemists in other countries in the same period, to see how national cultures shaped their public involvement. Second of all, Cohen's involvement could be put parallel to the activity of scientists from other disciplines, like organic chemistry, physiology and the humanities, to assess the role epistemological approaches play in the public engagement. Last but not least, it would be worthwhile to extend the scope beyond the university. Too often the focus is on professors, theory and 'pure science', while the many boundary figures that move in a grey area between pure and applied, theory and practice (like H.J. Prins and J.E. Enklaar) can offer very fruitful perspectives. Such accompanying perspectives are necessary to really address the public task of the university in its historical culture.

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