To be be published in *Proceedings of the 5th International Conference on the History of Chemistry*, Lisbon, Portugal, 6-10 September 2005.

PROVIDING METAPHYSICAL SENSE AND ORIENTATION: NATURE-CHEMISTRY RELATIONSHIPS IN THE POPULAR HISTORIOGRAPHY OF CHEMISTRY

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1. INTRODUCTION: THE SCIENTISTS' NEED FOR A META-NARRATIVE

Historians of science, like all historians, know well that every account of the history of science is necessarily an interpretation of the history of science. It requires decisions on what is important and what not, it requires ordering, contextualizing, and interpreting the available material, and presenting the results in a final form that sounds plausible to readers. Because a majority of the readers of histories of science are scientists, the degree of plausibility and acceptability depends on what scientists expect from the historiography of science. As a rule, scientists expect much, too much than historians of science can fulfill without giving up their scholarly standards.

Indeed, many scientist wish to read entertaining stories that make science, or their discipline, look particular attractive and interesting to a broader public. They may have their personal heroes, schools, or nations that they expect to be duly honored and celebrated. They want historians to focus on what they consider essential in order to carve socio-historical identities of disciplines or subdisciplines. They like to see progress in the historical development with one or the other revolution. They are yearning for meaning of the historical whole, such that individual scientific activities, including their own, make sense in the whole, and that one can draw extrapolations from the past to provide directions and goals for the future.

In order to meet all these expectations, a meta-narrative is required that professional historians are reluctant to adopt. And so scientists are inclined to write their own histories of science for personal satisfaction. In chemistry, the most powerful meta-narrative that satisfies all the mentioned and other historiographic needs of chemists is a story about "chemistry versus nature". It was invented and is still cultivated by chemists alone, without support and without objections thus far, from historians of chemistry. While the story has provided strong metaphysical orientation to chemists, it has caused rather alienation and hostility outside of chemistry.

In this paper I will provide a brief history of the meta-narrative "chemistry versus nature". I start with the historical ingredients that were mainly taken from alchemy and 19th-century organic chemistry. After presenting the meta-narrative in its full-fledged form in Paul Walden nationalist history of organic chemistry, I discuss the three most important literary variants in 20th-century American texts: drama in popular histories of chemistry, moderation in popular texts of chemistry, and routine in official reports on chemistry. Finally, I analyze the metaphysical orientation and its costs regarding the scientific status and public image of chemistry.

2. HISTORICAL INGREDIENTS

Virtually every European alchemical treatise from the 14th to the 18th centuries includes a clarification of the relationship between alchemy and nature.[1] Typical phrases, like "imitating nature" and "surpassing nature", are summarized in Table 1. While they could draw on ancient Greek philosophy of technology and the teleological concept of nature,[2] alchemists used these phrases in a new way to express their personal view of the power and potential of the alchemical art, relative to the potentials of both God and nature, which was conceived as a quasi-personalized agency that drives the natural transformation of substances.

In the 17th and 18th centuries, the naive teleological notion of nature as a quasi-person was gradually replaced by the modern, non-teleological notion of nature, as the total of natural forces or natural laws that determine phenomena. However, it survived in all areas of scientific study that dealt with living organisms in the encapsulated form of a living force or vitalism. When chemists in mid-19th century began to criticize vitalism, they did so by two approaches. In the laboratory, they

reproduced substances isolated from plants and animals in order to prove that no living force was required for their synthesis. In their historical accounts of chemistry, they celebrated Wöhler's 1828 urea synthesis as the breakthrough of synthetic organic chemistry. Ironically, in fighting vitalism and establishing synthetic organic chemistry, the anti-vitalists revived the naive teleological notion of nature.[3] In order to point out the significance of their own synthetic achievements, they compared them with Nature's synthetic achievements. And in order to establish synthetic organic chemistry, they described Wöhler's urea synthesis as the first step of continuous improvements in the imitation of Nature.

In sum, while alchemists used a set of alchemy-nature relationships synchronically, mid-19th century chemists first employed one of these relationships diachronically, which formed the nucleus of the later meta-narrative.

Table 1: Alchemy-nature relationships in alchemical treatises

Typical phrases	Nature's role as quasi-person
Alchemy imitates / learns from nature	Teacher
Alchemy competes with / rivals nature	Rival
Alchemy surpasses / improves upon nature	Inferior
Alchemy dominates / masters / defeats nature	Dominated

3. THE META-NARRATIVE: A STORY OF PROGRESS

In the first comprehensive histories of organic chemistry from the late 19th and early 20th centuries – by Carl Schorlemmer (1889), Edvard Hjelt (1916), and Carl Graebe (1920) – the meta-narrative is not only absent, but even its nucleus, the Wöhler myth, is clearly rejected as an earlier historiographic artifact.[4] Although there might have been earlier versions around, the first full-fledged meta-narrative in book form appeared in Paul Walden's *Geschichte der Organischen Chemie seit 1880* (Berlin: J. Springer, 1941), which Springer published as a follow-up volume to the history by Graebe, who had died already in 1927.

Paul Walden (1863-1957), a Russian chemist and pupil of Ostwald who became naturalized in Germany in 1919 and then an early sympathizer of the National Socialist Party, is well-known for his nationalist and heroic style of history writing.[5] Because the book was meant to cover only the recent period since 1880, he started with a longish introductory chapter to provide a broad perspective ranging from the early past to the future of organic chemistry. It is in this chapter that Walden formulated the meta-narrative by putting the alchemical phrases into an order of historical progress.

At the beginning, Walden introduced Nature as the teacher of chemistry that aspires to imitate her works: "Is not Nature both the model and the educator [...] of the chemist [...]? Through his synthesis, he wants to reproduce the chemical compounds created by living Nature" (p. 5). After dwelling for some 30 pages on the imitating-nature theme, the teacher suddenly turns into a rival or competitor: "Chemistry can be the science that imitates and rivals Nature regarding the creation of organic substances" (p. 35). Shortly afterwards, we learn that chemistry had already won the competition in several instance, that it had already become superior to Nature: "chemical synthesis can go beyond the natural models and artificially create high-quality cultural goods that not only meet but even qualitatively surpass the products of Nature" (p. 37). Eventually the meta-narrative ends with an outlook of future chemistry that will be able to control and master Nature: "chemistry will begin to direct, in accordance to their conditions, the processes in the living organism and to design them for the benefit of humanity" (p. 49).

Like alchemy and the anti-vitalists, Walden's meta-narrative drew on the naive teleological notion of nature as a quasi-person. The simple historical arrangement of the alchemical phrases – from imitating to rivaling, surpassing, and controlling Nature – should soon become the most powerful tool of chemists for metaphysical orientation. Before analyzing its orientational functions and its prices, I will give a brief sketch of its spread in the form of three important variants.

4. VARIATIONS

The meta-narrative has appeared in variations depending on text sorts and social contexts. Most commonly is the short-cut version that simply omits the final, and most provocative, step of 'mastering nature', particularly, since the metaphor has received severe criticism from environmentalist and eco-feminists.[6] Apart from that, three characteristic variants abound: (1) 'drama' in popular stories of chemistry, (2) 'moderation' in popularizations of chemistry, and (3) 'routine' in reports on chemistry and, more recently, on nanotechnology.

4.1 Drama

One of the most influential 20th-century popularizers of chemistry was the American chemistry schoolteacher Bernard Jaffe (1896-1986). In the mid-30s he wrote three popular histories of science that he republished in numerous revised editions throughout his life. The first one, *Crucibles* (1934, 1942), was a biographical history of chemistry that should become, under the subtitle of *The Story of Chemistry from Ancient Alchemy to Nuclear Fission* (1948, 1976), perhaps the most widely read history of chemistry book in English – it is still published today by Dover. The second book (series), from *Outposts of science* (1935) to *Men of science in America:* (1944, 1958, 1980) focused on more recent and contemporary American scientists. The third one, which narrated the achievements of the chemical industry in early the 20th century and which was published as *New world of chemistry* (eleven editions from 1935 to 1959) and then *Chemistry creates a new world* (1957, 1962), became his greatest success as a writer, particularly since the 1957 edition was introduced by Glenn Seaborg.

The key to Jaffe's success was his talent to write the history of science as drama.[7] Always bordering on fiction, his chemical heroes were fighting existential struggles in their quest for groundbreaking discoveries and inventions for the benefit of humanity. Because he believed in science as a model of comradeship rather than of competition, his dramatic heroes required a non-scientific opponent, for which he chose nature. "Such is the essence of science – the spirit of comradeship and good will in the entrancing work of piercing nature's secrets." (*Crucibles*, 1948: 132) From the outset, nature is not a benevolent teacher, but somebody who is reluctant to give away her secrets. Thus, instead of learning and imitating nature in a friendly atmosphere, Jaffe's heroes entered a battle. They needed to invent "ingenious devices for cornering nature in its most inaccessible places" (ibid., 202). And they needed to work together against their opponent, such that "students from all over the world fought valiantly for the mastery of nature" (ibid., 206).

His meta-narrative allowed Jaffe to unite everything, from physical chemistry to organic chemistry and industrial chemistry, within the same drama because they were all fighting the same battle against nature. Physical chemists were "cornering nature", organic chemists were "piercing nature's secrets", while the industrial "synthetic chemist has fought it out with nature on many a different battlefield [such that, for instance] almost 90% of it [rubber] came not from nature's plant but from chemical vats." (*Chemistry* 1957: 190). In the synthetic/industrial part of the drama, Wöhler is, of course, the crucial hero. Before Wöhler, chemists thought, "Man could never imitate the power of this vital force." (*Crucibles*, 1948: 129). After Wöhler chemists "fashioned thousands of new chemical compounds and imitated and even improved on nature in scores of instances." (*Chemistry* 1957: 234). Eventually, "chemists are searching for new products which nature in all her lavishness neglected so create." (*Crucibles*, 1948: 337 and *Chemistry* 1957: 321).

4.2 Moderation

While Jaffe's drama continued to be published in new editions in the 1970s, the notion of "chemists-fighting-nature" fueled severe environmentalist critique of chemistry. It happened that the American Chemical Society had its centennial in 1976, in the heydays of that criticism, and they used the opportunity to explain to the largest possible public that the notion is entirely misleading. In order to do so, they commissioned John H. Woodburn, a professional chemistry educator and talented writer, to write a popular and colorfully illustrated account of what chemistry is really

about. The outcome, *Taking things apart & putting things together* (Washington: American Chemical Society, 1976), was a rhetorical masterpiece that was broadly disseminated into the American classrooms.

The text starts out with praising "nature's chemistry" instead of nature: "Nature's chemistry is never turned off. [...] Nature's chemistry is fantastically successful. [...] is fascinating" (3). A subsequent chapter, entitled "People gain much from nature's chemistry", expands on the theme and concludes with "many materials which come to us by way of people taking lessons from nature's chemistry." (8) In the first chapter, the first period of the meta-narrative, admiring and learning, suddenly turns into the second and third period of rivaling and surpassing:

> But people are not only content simply to admire nature's chemistry. They want to understand. People are uneasy when they are dependent on actions they don't understand and, consequently, can neither manage nor control. People want a piece of action; they want to be free from blind dependence on nature's chemistry. They want to progress, to make better use of or even go beyond nature's chemistry. (3)

Instead of giving up the meta-narrative "chemists versus nature", Woodburn arranged it anew by renaming the actors. Instead of "chemists" he wrote "people", which should also comprise people who had made themselves the advocates of nature. Thus, it was no longer a story about chemists and their obsession with nature, it was a story of all of us. And instead of "nature" he wrote "nature's chemistry". By putting the emphasis on this side now on chemistry, those who loved nature had to love chemistry as well. In the rearranged meta-narrative, "people versus nature's chemistry", the same old story was told again with the actors' names being almost exchanged. While Jaffe exaggerated the meta-narrative in his drama, Woodburn took the opposite direction and moderated the tension by ingenious rhetoric that should help fend off the environmentalist criticism of his time.

4.3 Routine

A particular text sort of science are reports on the state of the art commissioned by governmental bodies or professional societies. These reports are usually written by distinguished experts, but addressed to a general audience, comprising the scientific community, science policy makers, and the interested public. Because they both summarize past achievements and provide recommendations for future developments, reports need to employ a diachronic structure, i.e. they need to tell a story that starts in the past and then smoothly moves on to the future. And because they are meant to provide orientation, reports are particularly susceptible to meta-narratives. Thus, it is not surprising that we find the meta-narrative also in chemistry reports. However, particularly in US reports, the shortcut version, from imitating to improving on nature, was so widely and routinely employed that it became the standard form of chemists to provide orientation and to express progress.

For instance, in the famous *Pimentel-Report* of 1985,[8] almost any field of chemistry was framed in the meta-narrative. Some fields were said to be still in the early stage, such that chemists still "want to learn how Nature has solved these extremely complicated chemical problems" (80), which included photosynthesis (42, 119), stereochemical reactions (78), bioinorganic chemistry (80), hormones (108), and immunological chemistry (138). In other fields, chemists had taken their lessons and were already in the stage of surpassing nature. "Chemical synthesis can also improve upon what nature has provided. [...] Thus synthetic chemists have been able to follow a lead provided by a natural product to design and prepare a new molecule with even better biological and chemical properties." (155) This was said to be the stage of polymers (48), natural products (76, 155), and antibiotics (128).

For a third group of fields, the meta-narrative was used not so much to describe their current state than to outline their future prospects and to give directions. Thus, in contrast to their still rudimentary learning state, the biochemical fields were portrayed as ambitiously moving on to the higher stages. For instance, in enzyme chemistry, where "Nature contrives a molecular surface suited to a specific reactant" (30), the reader was promised that "The earliest successes are likely to be patterned after natural enzymes, but there is no doubt that, in time, artificial, enzyme-like catalysts will not be limited to what we find already known in nature" (31, also 150). The most ambi-

tious portraits were those of biotechnologies. In recombinant DNA technology "scientists are learning to alter the actual blueprints so nature's factory will make a new substance that was not in its product line before."[9] It is only in these fields that the highest stage of mastering nature was employed in visionary terms of "controlling nature's biotechnology" (144) or "to engineer superior microorganisms" (161).

The *Pimentel-Report* helped establish the meta-narrative in this text sort, such that later reports on chemistry routinely employed it. Moreover, in subsequent reports it became the standard rhetoric at the very beginning of their "executive summaries". Thus, the follow-up report *Research Opportunities in Chemistry* (1994)[10] started right away with: "Science and engineering have entered an era in which new materials can be designed and optimized, as opposed to the former situation in which materials provided by nature were adapted to use. Chemistry plays a central role in this design process." (p. 1) And *Beyond the Molecular Frontier* (2003)[11] pointed out: "A key goal of the chemical sciences is the creation of molecules and materials that do not exist in nature. [...] The ability to design and synthesize new substances offers the possibility of improvement on what is found in nature" (p. 2).

When science policy makers in the US created, launched, and then promoted their National Nanotechnology Initiative (NNI) by numerous reports published since 1999, they could draw on the standard rhetoric established by the earlier chemistry reports. The talk of "imitating nature" and "improving upon nature" abounds in any of these reports, from the more technical ones, like *Nanotechnology Research Directions* (1999) to PR brochures, like *Shaping the World Atom by Atom* (1999). Given the fuzziness and hype of nanotechnology, and the arbitrary use of the nano-label, science policy makers have been much in need to bring metaphysical orientation to their mind-child, for which the meta-narrative appears to be just the ideal tool.

5. METAPHYSICAL ORIENTATION AND ITS PRICES

The meta-narrative provides metaphysical sense, orientation, and directions to chemists, which they otherwise seem to miss badly. Putting chemistry on par with, as Robert Boyle once said,[12] a "semi-deity", "a kind of a goddess, with the title of nature", moves chemistry to higher ranks. And inasmuch as "chemistry versus nature" echoes the older opposition of "culture versus nature", it suggests that chemistry is the essential part of culture. Apart from these implicit attempts to raise the social status, all such oppositions pretend to grasp the world as a whole, i.e. they provide a metaphysical worldview in which everything belongs to either side and in which both sides are intimately related to each other. In the framework of "chemistry versus nature", any chemical achievement, say the synthesis of the 30 millionths or so substance, has a metaphysical dimension because it affects the chemistry-nature relation. Thus, the meta-narrative serves to raise the significance of any chemical work from the local context of research problems, which are difficult to communicate, to metaphysical dimensions that easily communicate to a broad public.

By periodizing the metaphors in the meta-narrative, from learning from nature to mastering nature, a historical dimension is added that serves many important purposes of chemists. First, it allows seeing the history of chemistry as continuous progress and thereby provides, second, historical meaning and, third, unity to a vast and diverse field of research activities. The progress perspective allows, forth, identifying heroes in the history of chemistry, and, fifth, interpreting one's own individual work as a contribution to that progress. Sixth, because of the metaphysical framework, any such progress in chemistry can be viewed as progress of the entire world. Seventh, the meta-narrative allows localizing each activity, by both individuals and entire research fields, within the predetermined series of steps and thereby, eighth, measuring the state of progress. Finally, ninth, the predetermined series of steps provide orientation and goals for the future, both for chemists in their research and for science policy makers in propagating, funding, and publicly justifying "new" research directions.

The metaphysical orientation that chemists receive by the meta-narrative has its prices however. The orientation depends on the powerful but ridiculous fancy of a personalized nature. While in all the other scientific disciplines nature is, by definition, the object of study, chemists have culti-

vated it to be something opposed to chemistry, such that "chemical versus natural" appears to be a meaningful phrase unlike "physical versus natural" or "biological versus natural". The notion thus undermines the scientific status of chemistry to the extent that somebody who sees himself in competition with a personalized nature may cause doubts about his scientific understanding, if not mental state. It poses a barrier to interdisciplinary collaboration with researchers from other disciplines.[13] And it may have contributed to the chemical obsession with synthesis at the expense of studying and explaining chemical phenomena.

Inasmuch as the meta-narrative provides a feeling of metaphysical orientation, it lets chemists neglect to reflect on real orientation issues. What are the aims and methods of chemistry? How is chemistry distinguished from physics, biology, materials science and engineering? What is the place of chemistry in society? Where does current chemistry come from? The more chemists rely on their naive meta-narrative and its narrators, the more do they ignore any serious reflections on chemistry by historians, philosophers, and sociologists.

Finally, it happens that there is one other important group in western societies that shares with chemists the idea of a personalized nature. The relation to chemistry is so strong that they even took over an important notion from a chemist, James Lovelock's notion of Gaia, i.e. the earth as a living being. Yet, the meta-narrative of environmental fundamentalists, while including about the same notion of nature, has opposite normative implications. Instead of "from learning from nature to mastering nature" it is about praising, harmonizing with and sustaining nature, such that for those who love nature hating chemistry would be the natural consequence. The clash between these two meta-narratives could not be greater. By cultivating their meta-narrative, both for themselves and in public, chemists have cultivated and reinforced strong public hostility in times when environmentalist ideas are broadly accepted. From a PR perspective, one might observe that the meta-narrative of chemistry is about the worst idea one can imagine.

NOTES

[1] For more details on this and other historical ingredients see J. Schummer: "The Notion of Nature in Chemistry", *Studies in History and Philosophy of Science*, **34** (2003), 705-736, and the literature quoted therein.

[2] See J. Schummer: "Aristotle on Technology and Nature", *Philosophia naturalis*, **38** (2001), 105-120.

[3] As an illustration of the teleological jargon of anti-vitalists, Edward Frankland and Hermann Kolbe wrote: "Nature created the manifold and various products of vegetable and animal life [...] for the fulfillment of her great goals." (*Annalen der Chemie und Pharmazie*, 1848)

[4] C. Schorlemmer: *The Rise and development of organic chemistry*, London & New York: Macmillan, 1894, p. 22; E. Hjelt: *Geschichte der organischen Chemie von ältester Zeit bis zur Gegenwart*, Braunschweig: Vieweg, 1916, p. 363.

[5] See his *Dreitausend Jahre Chemie*, Berlin: Limpert, 1944.

[6] The most famous books for each kind of criticism are Rachel Carson, *Silent Spring*, New York: Fawcett Crest, 1962, and Carolyn Merchant: *The Death of Nature*, San Francisco, CA: Harper & Row, 1980.

[7] On the need for drama in popular history of chemistry books, see Philip Ball: "Chemistry in soft focus", *chembytes e-zine*, 9 (2002) [http://www.chemsoc.org/chembytes/ezine/2002/ball_sep02.htm].

[8] *Opportunities in Chemistry*, Committee to Survey Opportunities in the Chemical Sciences, National Research Council, National Academy Press, Washington DC, 1985.

[9] This sentence appeared only in the later short version of the report, *Opportunities in Chemistry: Today and Tomorrow*. ed. George C Pimentel & Janice A Coonrod, National Research Council, National Academy Press, Washington DC, 1987, p. 92.

[10] *Research Opportunities in Chemistry*, Office of Naval Research, Commission on Physical Sciences, Mathematics, and Applications, National Academies Press, Washington DC, 1994.

[11] *Beyond the Molecular Frontier: Challenges for Chemistry and Chemical Engineering*, Committee on Challenges for the Chemical Sciences in the 21st Century, National Research Council, National Academies Press, Washington DC, 2003.

[12] Robert Boyle: *A Free Inquiry into the received Notion of Nature* (1682), in: *The Works*, ed. Thomas Birch. London, 1772, vol. 5, pp. 164, 191.

[13] J. Schummer: "Interdisciplinary Issues of Nanoscale Research", in: D. Baird, A. Nordmann & J. Schummer (eds.), *Discovering the Nanoscale*, Amsterdam: IOS Press, 2004, pp. 9-20.