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Rethinking Research in the Chemical Industry: Organizational History of Centre de Recherches d'Aubervilliers (1953–2020)

Abstract

Solvay's Centre de Recherches d'Aubervilliers (CRA) is one of the oldest active private-sector research centers in industrial chemistry in France. During the seventy years of its existence it collaborated with some of the most significant French and European chemical companies. Established in 1953, the center's research and development organization around huge discipline-oriented laboratories proved itself remarkably resilient. Not merely reflecting the R&D policy of the company that owned it at a given moment, the evolution of the center's research organization followed its own particular path. The research priorities in any given moment were always a place of encounter between top-down requirements of the company's directorship, and bottom-up thematic trajectories. The CRA's organizational history gives us unique insights into broader

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tendencies in chemical research in the second half of the 20th century, such as specialization of laboratories, introduction of market-driven research as well as decentralization and multiplication of hierarchies. The case study can be of interest to historians of science, due to the fact that the history of private research centers remains largely understudied, and to science policy scholars who want to understand the interconnectedness of factors that influence the organization of R&D structures in an institution.

Keywords: R&D *management, chemical industry, industrial chemistry, science policy, history of science in France, market-driven research*

Perspektywy na temat badań i rozwoju w przemyśle chemicznym: Historia organizacji centrum badawczego w Aubervilliers (1953–2020)

Abstrakt

Centrum Badawcze w Aubervillers (Centre de Recherches d'Aubervilliers – CRA), należące dziś do chemicznego giganta Solvay, jest jedną z najstarszych wciąż funkcjonujących prywatnych instytucji naukowych we Francji. W ciągu ostatnich 70 lat, centrum prowadziło badania na rzecz największych francuskich i europejskich grup chemicznych. Od momentu powstania w 1953, jego struktura zorganizowana była wokół dużych dyscyplin naukowych. Specyfiką struktury badawczej centrum był fakt, że nie odzwierciedlała ona wyłącznie polityki firmy, do której centrum należało w danym momencie, ale jej ewolucja kierowała się swoją własną logiką. Priorytety naukowe centrum były wypadkową strategii handlowej firmy oraz poprzednio istniejących trajektorii naukowych. Historia organizacji CRA daje szansę na lepsze zrozumienie głównych tendencji w polityce naukowej prywatnego sektora w drugiej połowie XX wieku, takich jak specjalizacja laboratoriów, tzw. *market-driven research*, czy też decentralizacja hierarchii. Historia CRA może być punktem odniesienia zarówno dla historyków nauki, ze względu na fakt że prywatne centra badawcze są często nieobecne w literaturze przedmiotu, oraz specjalistów z zakresu

polityki naukowej, którzy pragną zrozumieć współzależności różnych czynników kształtujących organizację działów badania i rozwoju w prywatnych firmach.

Słowa kluczowe: *zarządzanie badaniami i rozwojem, historia przemysłu chemicznego, polityka naukowa, historia nauki we Francji, historia chemii*

1. Introduction

The Centre de Recherches d'Aubervilliers (CRA) is a private research center established by the French chemical and metallurgical giant Pechiney in 1953 in Aubervilliers, a small industrial district north of Paris. Through a series of acquisitions and transfers that took place over the last seventy years, the center, home to about five hundred engineers, technicians, and administration employees, circulated between the most important French chemical companies: Pechiney-Saint-Gobain, Rhône-Progil, Rhône-Poulenc, and Rhodia. Today it belongs to Solvay, the international chemical corporation of Belgian pedigree. Each of these companies had its own R&D policies and conducted activities in different markets. The center had to negotiate its place inside every company's R&D structure in order to preserve its identity. However, this identity was far from static. On the contrary, the CRA's internal organization has been thoroughly reshaped throughout the decades, often on its own initiative. Unpacking the black box of its organizational history uncovers a tangled evolution of the center's laboratories as well as deep shifts in the understanding of what research in the private sector is and should be in the second half of the 20th century and the first years of the 21st century.

Because of its particular narrow focus, this study constitutes an original approach to the contemporary history of science policy. of course, the issue of R&D organization in private companies is at the heart of entire journals, such as *Research-Technology Management*, and specialized publications exploring the intricacies of the innovation-friendly research infrastructure are plentiful (Argyres and Silverman 2004; Tirpak et al. 2006; Akhilesh 2014; Aggarwal, Hsu and Wu 2020). The historical approach to research policy and management in the chemical industry has also garnered attention, either in works specifically devoted to the problem of R&D in the firms (Hounshell and Smith 1988; Le Roux 1998; Christensen 2015) or in works exploring the history of chemical giants in general (Verg et al. 1988; Abelshauser et al. 2003; Bertrams et al. 2013).

And yet all these studies, newer and older, involving a more historical perspective or focusing strictly on contemporary challenges, share a common element: they usually discuss R&D on a macro level with a top-down approach to organizational challenges inside a given company. They often tend to leave out the micro level – the structure of particular R&D units, research centers, and laboratories. In fact, the question of the organization of individual research institutions was always the domain of historians, sociologists, and anthropologists of science. Studying entities such as learned societies (e.g. Hahn 1993; Seitz 2007; Tinniswood 2019), institutes of industrial research (e.g. Paul 1980; Fonteneau 2010; Krasnodębski 2018), and all sorts of laboratories (e.g. Pestre 1990; Leland and Schaffer 1994; Holl 1997) is perhaps the most classical approach in these disciplines. As rich as these studies are, they only seldom explore the issue of R&D organization and management in the private sector laboratories in the post-1945 era (for an older example see Reinhardt 1998). Because of that, there is a number of problems that remain rarely explored by historians of contemporary chemistry, especially concerning the last 50 years. For example, what language was used to describe the division of labor in research centers and how it changed over the decades? Or, what were the major tendencies that shaped the development of the organization of laboratories in the chemical industry? This is, of course, not to say these problems have not been already studied at all. For example, excellent works on R&D in the companies such as the French Pechiney (Le Roux, 1998) and the Dutch DSM (Van Rooij, 2007) give many invaluable insights. And yet, these works are, again, top-down oriented and they adopt the firm's point of view on the organization of research activities. In this paper, I discuss these issues insisting more on the bottom-up approach, by analyzing the development of the CRA's structure from 1953 to 2020. What makes the CRA stand out is the fact that some of the most substantial organizational changes did not coincide with the transition of ownership, but were either advocated from the inside or resulted from the center's organic adaptations to the corporate strategy. These reforms often stemmed from broader global mentality shifts in the way it was belived research should be organized, or constituted adaptations to new economic conditions. In this sense, the lessons taken from the CRA's history may have the potential to illustrate much larger phenomena.

The originality of this paper is thus threefold. First, it studies the R&D structure on the micro level, inside a research unit itself. Unlike many other studies on corporate R&D management on the macro level, it explores the evolution of one center's internal structure, its rationale, and challenges. Second, because our object of inquiry circulated between different companies for a period of seventy years, its history can give us insights concerning R&D organization beyond the logic of individual firms and illustrate more general tendencies. Last but not least, the interest of the study stems from the case study itself: there is virtually no overview of big trends in the history of the chemical industry in France in the last decades of the 20th century and the first years of the 21st century. Even the most comprehensive works on disciplinary developments in French chemistry rarely discuss the contributions of the private sector (Voillequin 2010; Teissier 2014). In this sense, this article constitutes a pioneering work when it comes to the history of the French private sector R&D in the chemical industry in the second half of the 20th century and first decades of the 21st century.

The hypothesis of the paper is straightforward: the way the center was structured was not merely the result of the company's research policy in a given period. On the contrary, we can identify through the center's history 1) a form of organizational inertia that proved to be particularly resilient over time; and 2) an internal logic of development due to the evolution of competencies present on the site. To put it differently, the organization of the CRA was a constant re-articulation of top-down expectations of the company and bottom-up organizational trajectories.

The paper is divided into four chronological parts. In the first, I look into the CRA's origins and the reasons behind its initial organization, as well as study its structure for the first twenty years (1953–1975). In the second part, I explore the reorientation of the CRA's organization under Rhône-Poulenc in the late 1970s and the 1980s, and the growing specialization of the center. In the third part, I study the major reform of CRA in the 1990s and the concept of market-driven research that was behind it. In the final part, I look into the massive restructuring in the years 2000–2010 following Rhodia's economic difficulties, as well as the impact of the acquisition by Solvay. The paper concludes with a more theoretical overview.

2. Origins of stability: Prehistory and early history of the CRA's organization (1953–1975)

Table 1: Companies owning the CRA throughout its history

Years	Owner
1953–1961	Pechiney
1961–1971	Pechiney-Saint-Gobain
1972–1974	Rhône-Progil
1975–1997	Rhône-Poulenc
1998–2011	Rhodia
2011–Present	Solvay

Table 1 shows the major chemical companies that owned the CRA over the last seventy years. Some of them were key global players: Rhône-Poulenc was the largest French chemical firm in the 1980s, Rhodia was a huge French company that started as Rhône-Poulenc's spin-off for chemical activities in the 1990s, and Solvay is in the top ten European chemical companies. Others were short-lived subsidiaries: Pechiney-Saint-Gobain was, unsurprisingly, a subsidiary of Pechiney and Saint-Gobain focused on chemistry, and Rhône-Progil was an ephemeral entity controlled exclusively by Rhône-Poulenc that was rapidly integrated directly into Rhône-Poulenc's structure.

As important as the transitions between different companies were for the center's history, they were only what was visible on the surface. Other important transformations happened behind the scenes. For example, Pechiney-Saint-Gobain was bought by Rhône-Poulenc in 1969 (leading to a curious situation in which the company, named Pechiney-Saint-Gobain, co-existed with both Pechiney and Saint-Gobain, none of them having control over it). Another important event was the nationalization of Rhône-Poulenc in 1982 and its privatization in 1993, making the French government a stakeholder in the center's story. In fact, the CRA was at the heart of some of the key moments in the history of the French chemical industry.

In spite of these frequent changes of ownership, it is remarkable to note that the center's basic organization did not substantially change between 1953 and 1988, and some of its essential elements survive

today. The French metallurgical and chemical giant Pechiney set up this initial structure in 1953.

Pechiney (initially known under the name Compagnie des Produits Chimiques Henri Merle and later as Produits Chimiques d'Alais et de la Camargue) was founded in 1855. In the 1860s, it became known as a major producer of aluminum and later, at the beginning of the twentieth century, for its contributions in the field of electrometallurgy (Gignoux 1955; Vindt 2006). During World War I, at the demand of the French government, the company opened facilities to manufacture chlorine for combat gas. After the end of hostilities, instead of closing the factories, the company's directorship decided to re-purpose them for civilian use. New ways had to be found to profit from the substance and in order to address the issue, a new chemistry department focusing on polymers and organic chemistry was set up. In these early years following World War I, the company had no general research policy, strictly speaking. Research on products and processes was conducted in small laboratories attached to the company's major factories. However, in the 1920s one of the company's leading chemists, Professor Alfred Guyot, advocated establishing a 'central laboratory' that would bring together the company's chemists in a single place (Le Roux 1998: 161). No proper research center was created back then, but Guyot, as a temporary solution, established his central laboratory in the company's factory in Salindres in the south-east of the country. This small unit was meant to address the long-term challenges encountered by Pechiney's chemistry department, unlike the 'normal' factory laboratories, that were above all to provide continuous support to production units (Salindres had a separate laboratory devoted specifically to its internal problems).

After World War II, Pechiney, like many other French companies at the time, started to consider the American industry as an example of successful and rational management to follow. It contacted the agency of Henry W. Clark, one of the fathers of the modern management methods (and of the Gantt charts), in order to conduct a major study to rationalize the company's organization (Kipping 2002: 277). The study itself was conducted by one of Clark's associates in Europe, K. B. White, who led the project between 1947 and 1952. White, while generally in favor of decentralization, with separate hierarchies in different departments, made a major exception for R&D in the department of chemistry. He suggested bringing the department's largest laboratories together in order

to optimize the investment in expensive equipment required by these facilities. This advice remains fully in line with broader tendencies over the period: in 1949, the Monnet plan advocated the centralization of research activities in the French chemical industry (Le Roux 1998: 273).

The company's directors followed White's advice and, from the late 1940s, the project of creating a new unified research center entered the agenda. Various locations were considered and, after lengthy discussions, Paris and its suburbs were favored. Maurice Fréjacques, chief officer of Pechiney's Research and Documentation Service, called Paris a "cyclone of ideas" where national and foreign researchers met and where the center would find many suppliers of industrial equipment along with well-equipped libraries (IHA Archives 1). In practice, it was widely understood that Paris was attractive to the country's best young engineers that might not be willing to move to a facility established "in the provinces". Again, the exact location was a matter of debate, but the industrial zone of Aubervilliers, north of the city, was chosen due to the fact that Pechiney owned a factory there and an area big enough for the new center.

In its first days, the newly created Centre de Recherches d'Aubervilliers brought together engineers and technicians from four of Pechiney's sites: three small laboratories in the Parisian region and the company's 'central laboratory' in Salindres, which accounted for more than half of employees in the young CRA (Anonymous, 1954). Formally, the center was divided into three separate functions: 1) administration; 2) the pilot plant and chemical engineering; and 3) the scientific function (CRA Archives 1). This last was the largest, comprising around two-thirds of the center's staff. The scientific function was the heart of the center and I will focus mostly on its laboratories in the first part of the paper.

While Pechiney was first and foremost an electrometallurgical company famous for its aluminum, its chemistry department was above all devoted to organic and polymers chemistry. This led to the division of the CRA's scientific function into four principal laboratories dealing with: 1) organic chemistry; 2) macromolecular (polymer) chemistry; 3) inorganic chemistry; and 4) plastic applications, to which we can add 5) a transversal laboratory of physics, which would become a laboratory of physico-chemistry and analysis in later years. We can observe their main topics of interest and their relative sizes in the first years of the center in Table 2.

Table 2: CRA's scientific function: relative size in 1955 and major topics of interest in the years 1953–1960

Laboratory	Inorganic (mineral) chemistry	Organic chemistry	Macro-molecular chemistry	Plastic materials applications	Physics
Employees in 1955	19	50	37	26	24
Main topics of interest	Alumina gels, aluminum oxides, lithium salts, fluorite, chloride, chromium	Vinyl chloride, organic chlorine derivatives, propane, olefins	PVC, polystyrene, polyesters, polyvinyl acetate, polyolefins, polyethylene	PVC, Polystyrene, Polyesters	Services to other laboratories (microscopy, X-rays, calorimetry etc.)

Source: CRA reports 1953-1960

Table 2 shows a few interesting phenomena. First, the inorganic chemistry laboratory was the smallest with only 19 employees (out of 156 in the scientific function) in 1955. It played a curious role. It was not a part of Pechiney's electrometallurgical department (central to the company's identity), but remained on the margin of the chemistry department as well due to the laboratory's heterogeneous activities often unrelated to the Center's main research topics close to organic chemistry. Second, we can observe that polymers were at the heart of the center's activity with two laboratories studying them: macromolecular (upstream) and plastics applications (downstream). Third, while the laboratory of organic chemistry, the largest in the CRA, to an extent played a supportive role to the two aforementioned laboratories (studying for example vinyl chloride), it had also its own independent research agenda. Fourth, the physics laboratory was more of a collection of smaller semi-autonomous units providing services than a proper research laboratory, even though its directorship tried to create a common identity and underlined that, unlike the chemical engineering department, it was part of the research function (CRA Archives 2).

The most striking element of this organization, however, is the fact that it revolved around broadly construed scientific disciplines. of course, the laboratories were divided into more focused sections on raw materials/products (for example PVC or fluorides), but their names could almost be titles of general chemistry textbooks. This expressed an important idea: the laboratories were supposed to be pools of expertise to be tapped by the company depending on the problem encountered. When a given product entered the portfolio of the company, it became attached to the laboratory from the relevant discipline. For example, when Pechiney decided in 1957 to establish a latex workshop in its largest PVC and plastics factory in Ribécourt, latex automatically became the subject of studies in the CRA's macromolecular and plastics applications laboratories, which assisted Ribécourt on a daily basis (Anonymous 1962). In this case, extension of the competence in the field of polymers was a natural step, but this was not always the case. When Pechiney bought a rare earths factory in La Rochelle in 1959, almost no previous experience in rare earths or similar elements was present in the CRA (Berbain 1960). However, because studies on rare earths belong to inorganic chemistry, it was the inorganic chemistry laboratory that had to address the challenges encountered in the factory. We can imagine alternative solutions, such as the creation of a separate laboratory devoted uniquely to this subject, and yet it was decided to keep the disciplinary labor division intact.

It must be underlined that in spite of how close the laboratories and the factories were, from a formal point of view the CRA's employees were not attached to Pechiney's divisions or business units, but were part of the centralized R&D structure that had a huge degree of autonomy. Individual business units, even after the establishment of the CRA, still had their own smaller laboratories answering everyday problems in the factories themselves. Pechiney had then two R&D hierarchies: one decentralized and subjected to different divisions, and one centralized and autonomous. The guardian of the center's independence and a negotiator between its laboratories and the company's divisions was the CRA's director, Xavier Thiesse, graduate of the famous Ecole Supérieure des Industries Chimiques in Nancy and Pechiney's chemist previously in Salindres, who was the head of the center from its inception in 1953 to his retirement in 1976. He was responsible not only for scientific affairs, but also for what we would call today human

resources. He supervised internal communication, contributed to the integration of the employees (for example hosting sports activities), and supervised the site's extension (the construction of new buildings and the installation of new laboratories and services).[1] Thiesse's long tenure and the extent of his powers as director reflect the broader trend in French academic chemistry in the post-War period, often dominated by the 'mandarins', figures of authority shaping the identity of laboratories, as well as crafting their future directions and policies (e.g. Teissier 2014). The directors that followed Thiesse, as important as they were in influencing the center's policy, kept their positions on average for no more than four years, and never had the impact he did on the center's identity. Interestingly, Thiesse was not directly involved in the scientific management of the center, but relied on his vice-directors and chiefs of individual laboratories. In other words, his policy was to keep things simple and make the center a self-organizing unit in which things fell naturally in their own place.

The center's structure proved remarkably resilient in spite of the potentially disruptive shifts that took place on the company level in the years following its birth. In 1961, just eight years after the center's establishment, Pechiney and another French industrial giant, Saint-Gobain, decided to create a common subsidiary devoted to chemistry. In other words, the two companies separated their chemical departments and placed them in a company called Pechiney-Saint-Gobain (Wei 2016). At the same time, both Pechiney and Saint-Gobain continued their activities on their core markets: aluminum and glass, respectively.

This changed the CRA's position inside the company. While it had been the only chemical research center in Pechiney, in Pechiney-Saint-Gobain it was complementary to another research center in the south of Paris, in La Croix-de-Berny (CRB), established by Saint-Gobain in 1954. The two centers had to collaborate. Some teams (notably inorganic catalysis) were transferred from the CRA to the CRB (Anonymous 1984); others created structures in common, for example, to focus on latex applications (Interview 2); and yet none of these moves affected the general organization of the CRA around its five major laboratories.

The subsequent acquisition of Pechiney-Saint-Gobain by Rhône-Poulenc (1969) and the integration of two centers into Rhône-Progil

[1] See CRA activity reports 1954-1976 (CRA Archives); also: Interview 1.

(1972-1974) had similarly little effect on the center's organization. The only major change resulted from the extension of the laboratory of inorganic chemistry in the 1960s: the number of staff quadrupled between 1953 and 1967 thanks to the company's investments in rare earths and phosphates. It became the largest laboratory in the CRA. One of its sections, devoted to mineralogy and collaborating with the company's mines and with its geological prospecting department, was separated and became an independent laboratory on its own. This new laboratory of mineralogy was a very small unit, however, having around ten employees in total throughout its existence. Created in 1968, it was dismantled ten years later and its employees reintegrated into the laboratory of inorganic chemistry. As such, this short-lived modification was not significant to the center's overall structure. However, when the center was integrated directly into Rhône-Poulenc in 1975, things were to change.

3. Specialization: Rebuilding CRA under Rhône-Poulenc (1975–1998)

Leaving mineralogy aside, between 1953 and 1974, the CRA's scientific structure remained organized around broadly construed academic disciplines. Its major laboratories had their roots in Pechiney's laboratories from before 1953. In 1975, two things happened simultaneously and independently. First, the organic chemistry laboratory disappeared. Rhône-Poulenc, unlike its smaller predecessors, had multiple large research centers and encouraged their specialization, and the laboratory of organic chemistry was transferred from Aubervilliers to Lyon (Interview 3). Second, the laboratory of latex applications was established. Latex was growing as a subject of interest in the 1970s, and while the macromolecular laboratory continued to provide more upstream expertise, latex applications became a subject so large that it was separated from the laboratory of plastics applications (that continued to work on PVC, polyesters, polyethylene, and other polymers). For the first time since 1953, the company's policy led to a substantial modification of the CRA's structure. Not only had one of the CRA's founding laboratories disappeared but, more importantly, the broad disciplinary logic was broken with a new laboratory focused exclusively on one product (though with multiple markets).

In 1978, another restructuring took place when Rhône-Poulenc decided to focus the profile of its La Croix-de-Berny research center exclusively on pharmaceutics. As a consequence, some of its main laboratories were transferred to the CRA, notably inorganic catalysis. We should clarify chronology at this point. Catalysis was part of the CRA's inorganic chemistry laboratory until the late 1960s. Then it was transferred to La Croix-de-Berny, only to come back again to the CRA in 1978. However, it was not integrated back into the inorganic chemistry lab, but became an independent unit on its own. It was a sign of a new tendency toward laboratories' specialization. In the following years, some other small restructurings took place as well. Notably, the analysis unit of the inorganic chemistry laboratory became an independent laboratory. As a consequence, for three years (1978-1981), inorganic chemistry was studied in three laboratories: inorganic catalysis lab, inorganic analysis lab, and inorganic chemistry lab (focused on synthesis). In 1981, the inorganic analysis merged with the physics laboratory, but overall there were few changes until 1985.

It is important to point out that these modifications of the center's architecture coincided with the retirement of Xavier Thiesse in 1976. The directors that followed him held this position for three years on average and operated within a completely different time frame than Thiesse. The restructuring of the CRA that started accelerating in the 1970s may be partly attributed to the fact that there was no more single 'pillar', such as Thiesse, with a single coherent vision of what the center should look like in the long run.

Meanwhile, things were also happening on the corporate level. In the middle of the 1970s, the CRA was attached to Rhône-Poulenc's research-focused subsidiary Rhône-Poulenc Recherches which grouped five different centers that provided services to the company's other departments. However, one by one, these centers specialized and were attached to individual departments in order to focus on specific markets. By the end of the 1980s, only the CRA and another center in Lyon (CRC, then CRL) were active in Rhône-Poulenc Recherches (Graulier 1987). Over the same period, in 1982, Rhône-Poulenc was nationalized by François Mitterand's government (Barral 2008, p.129). Yet again, none of these developments influenced the organization of the CRA itself.

Table 3 shows the evolution of the CRA's scientific structure throughout most of its history. Its careful reading reveals many

Table 3. Evolution of CRA's laboratories (1953–1994)

1953-1967	**Pilot/ Chemical engineering (G)**	**Inorganic (Mineral) chemistry (M)**	**Organic chemistry (O)**	**Macro-molecular chemistry (C)**	**Application of plastic materials (T)**		**Physics (P) + X ray laboratories (X)**
1968-1974	G	M	O	C	T	**Minera-logy (K)**	P + X
1975	G	M	O	**Latex applica-tions (AL)**	C	T	K	P + X
1976-1977	G	M	AL	C	T	K	P + X
1978-1981	G	M	**Inorganic catalysis (MC)**	AL	C	T	**Inorganic analysis (An)**	P
1982-1984	G	M	MC	AL	C	**Polymer applica-tions (AP)**	**Physics and analysis (P-An)**

1985-1987	G, **DI (Industrial develop-ment)**	M	MC, Cat	**Dispersion and polymers (DP)**	AP	P-An							
	First reconstruction (Small)												
1988-1989	DI	**Solution che-mistry (CS)**	**Inorganic Synthesis (SM)**	**Cata-lysis (CAT)**	**Mate-rials (MAT)**	DP	**Application of dispersions (AD)**	P-An					
1990-1991	Department of inorganic Chemistry					Department of Specialty Chemicals							
	DI	CS	SM	CAT	MAT	**Radi-cal poly-meriza-tion (PR)**	**Appli-cations of disper-sed poly-mers (APD)**	AD	P-An				
1992-1994	DI	SM	CAT	MAT	PR	APD	AD	P-An					
	Second reconstruction (Big)												

interesting phenomena. First, while in the first decades of the CRA's history, the pilot/chemical engineering (CRA/G) was treated as distinct from the scientific function, this began to change in the 1970s. This is in fact a broader historical phenomenon, involving the struggle for recognition of chemical engineering among French chemists not always welcoming toward the new discipline (Breysse 2014, pp. 21–58). Throughout the 1980s, some tasks that had belonged to CRA/G were transferred to administration (all sorts of maintenance activities, electricians and the like), while the CRA/G unit was becoming more and more professionalized until it took the name of the industrial development laboratory (CRA/DI) in 1986 and was fully integrated into the scientific function.

In 1985, another change took place. The macromolecular laboratory and the latex application laboratory were integrated into one single unit called dispersions and polymers, dealing mostly with latex on all levels of its development. More substantial changes followed in the years 1988–1991, after the first big reconstruction, when many new laboratories were formed: solution chemistry, materials, radical polymerization, and dispersed polymer applications. These changes were not due to some broader research management policy required by the company or because of the arrival of new markets into the center's perimeter. of course, as the company developed, acquired, and sold different activities throughout the 1970s and 1980s, corresponding services were created or dismantled in the CRA, but all this happened inside the pre-existing structures. When Rhône-Poulenc embarked on a new project involving ceramics in the middle of the 1980s, a special team was created inside the laboratory of inorganic chemistry, even though there were relatively few existing synergies, a history mirroring that of rare earths (Anonymous 1986). Therefore, the development of new markets had little direct effect on the way the CRA was built for many decades. The 1988 reorganization was above all an internal decision to create new synergies and hierarchies, as the old structure was considered obsolete and less and less relevant. It was a shift in philosophy of research organization. For example, with the rise of new disciplines such as materials science, the center created its own laboratory of materials, bringing together teams previously working on inorganic and polymer chemistry. The radical polymerization and dispersed polymer applications laboratories were above all a new configuration for

research into latex. A truly new laboratory, chemistry of solutions, also had some antecedents in the inorganic laboratory (Anonymous 1988).

What we clearly see is a tendency toward the specialization of laboratories that started with the latex laboratory in 1975, but was fully implemented in the late 1980s. The new organization was no longer built around broad disciplines but around much narrower fields of competence. This represented a radical departure from the previous philosophy: the laboratories were not broad pools of competence to be tapped, but their names were supposed to correspond to what was actually happening inside them; it was to be immediately obvious what kind of expertise they could deliver. This improved transparency toward stakeholders and inside the company itself, but reduced flexibility and required more frequent adaptations of the structure in the future.

In fact, this problem was identified back in 1990: to remedy it somewhat and to reintroduce a degree of stability in the organization, all the laboratories were divided into two departments, inorganic chemistry and organic chemistry, with an ambition to provide a common identity to two groups. This arrangement was artificial and short-lived. Notably, the materials laboratory was attached to the inorganic chemistry department even though it dealt, to a large extent, with polymers, while the industrial development section (CRA/DI) and the physical analysis laboratory (CRA/P-an) were attached to the inorganic and organic departments respectively not for objective reasons, but to balance the number of employees between the two departments (Interview 2). It is important to note that, unlike ten years before, this time no one doubted that industrial development and physics were both part of the scientific function, not the support function.

The specialization of the laboratories in the CRA preceded another tendency that was becoming more and more pronounced over the same period: market-oriented research.

4. Market-driven research in the CRA

The notion of market-driven research began to permeate the chemical industry starting from the late 1980s. While the phenomenon has not yet garnered significant attention from historians of science, it was clearly lived by the stakeholders themselves. One article from the period provides some insights into the issue:

> So what actually is market-driven research? It is a strategy that determines R&D priorities in areas that will have the greatest potential impact on the marketplace – it puts customer needs first because they translate quickest into sales and profits. (…) the technology is being tied more closely to the market and in some cases, is being driven by it (Chapman 1991, p. 1; see also Gross 2003).[2]

This approach, self-evident today, was a novel paradigm in the early 1990s. In 1993, when Rhône-Poulenc was privatized, market-driven research entered into the vocabulary of the company that was catching the wind in its sails.

In this paper, we have not delved so far into the analysis of the divisions of the companies controlling the CRA, but it is important to note that throughout the 1980s two Rhône-Poulenc sectors were principal clients of the center: 1) Chemical Specialties and 2) Organic and Mineral Intermediates. In 1995, they merged into one new chemistry sector, which was divided into a number of enterprises (later business units) working on end markets.

The official reason for the creation of the new sector was as follows:

> The increasing international competition, in terms of costs, quality, and innovation, modified the relations between clients and suppliers. Our clients turn more and more towards us, chemists, to preserve or reinforce their technological and commercial superiority, their capacity to innovate.
>
> The New Chemistry of Rhône-Poulenc has an ambition to support our customers in their challenges. It is up to us to offer them efficient solutions based on individually adapted products and services. The New Chemistry is not a new 'slogan', it represents the will of the Group to build its growth on a new approach to chemistry. Rhône-Poulenc wants to offer chemistry of applications and services. The key words of this New Chemistry are: 'innovation' and 'clients' (CRA Archives 3, p. 3).

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[2] This and all the quotations in this article are originally in French and were translated by the author.

This passage illustrates a new mindset driving the R&D management of the French chemical giant. The great restructuring of the CRA that took place in 1994/1995 followed this spirit, but one would be mistaken to think that it was somehow forced by the company. On the contrary, the initiative concerning the most radical reform of the center's structure in its entire history was shaped above all in Aubervilliers itself. This is attested in a 60-page draft prepared by the CRA's directorship in 1994 and presented to the company for approval (CRA Archives 4, p. 9). While the document lays down the results of debates among key scientists in Aubervilliers and not the debates themselves, it remains an invaluable insight into the rationale of the reform. Interestingly, while it may seem to be merely an internal R&D management regulation, it includes a serious epistemological reflection.

Broadly speaking, the new organization was built around four competence groups: 1) coatings; 2) dispersions/formulations; 3) reinforcement/consolidation; and 4) solid state chemistry and physics. Each group owned one "applicability" (*applicabilité*) laboratory and multiple application laboratories. These four groups were accompanied by four transversal services divided into two functions: synthesis and characterization (Table 4).

What we immediately see is the new focus on final markets: paper, paintings, cosmetics, construction materials, etc. of course, teams working in specific markets were present in the CRA before, integrated into individual laboratories; but from now on, they were clearly visible in the center's organization charts. Stakeholders were expected to grasp the center's profile in one glance.

Four common services are slightly trickier. Three of them belong to the 'synthesis function', the fourth to the 'characterization function'. The characterization function dealt with topics previously covered by the physics and analysis laboratory. Synthesis services, on the other hand, were structurally the same thing as the previously existing laboratory of inorganic chemisty (CRA/M). To put it differently, this laboratory switched from being a part of the core scientific function to the transversal shared one.

However, the most interesting element of this new puzzle is the applicability laboratories. The CRA's policy document explains that:

> As an ultimate objective, applicability has to define the optimal physico-chemical characteristics of the products in

Table 4. CRA research organization introduced in 1994/1995

Coatings group	**Formulations/ dispersions group**	**Reinforcement/ consolidation group**	**Solid state chemistry and physics group**
4 applicability laboratories corresponding to each group			
12 application laboratories			
– Paper – Paintings/adhesives	– Detergents – Cosmetics – Industrial formulations – Active materials formulations – Food additives	– Additives and mineral fillers for polymers – Construction materials	– Catalysis – Magnets – TV/lighting
Four shared research services			
Synthesis function		**Characterization function**	
– Synthesis and technology of polymers in emulsion – Inorganic chemistry synthesis – Inorganic chemistry technology		– Physical and chemical characterization	

Source: CRA Archives 4.

> view of the expected function (that has a practical value) in the given environment of usage (…) Applicability ensures a true continuity between application and synthesis and generates an important added value in the innovation process in the service of the client (CRA Archives 4, p. 9).

It is, in a sense, a missing link between transversal services and application laboratories. Figure 1 seeks to visualize these mutual interdependencies.

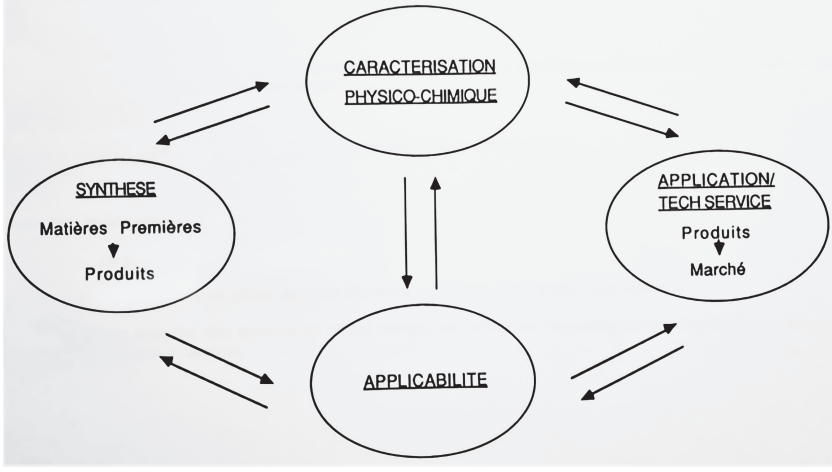

Figure 1. Four types of research conducted by CRA (1994)
Source: CRA Archives 4.

Employees did not universally acclaim the reform implemented by the directorship, though. An internal report by the Coatings Group noted some negative tendencies in 1995 concerning the newly gained autonomy of the application laboratories:

> a more decentralized functioning (…) spread rapidly. (…) The chiefs of the laboratories were quickly 'absorbed' by the business units, and the new logic of organization built around projects (…) positioned the barycenter of these laboratories at Doumer [the headquarters of Rhône-Poulenc]. This leads to identity-related difficulties and makes it hard to sensibilize these teams to the collective interest [of the group in its entirety] (CRA Archives 5, p. 21).

We see here signs of things to come. The application laboratories, unsurprisingly, were closer to the business units dealing with specific markets than to their own research groups in Aubervilliers. The multiplication of application-focused projects that brought together researchers from different institutions (often universities and other companies) led to further tensions, as these projects inevitably established hierarchies alternative to those inside the CRA. The applicability laboratories and the transversal functions (synthesis and characterization) were still deeply rooted in the CRA's pre-existing hierarchies, but the newly liberated application laboratories were more and more dependent on Rhône-Poulenc's market-focused divisions.

It is also worth mentioning that the entire philosophy of market-driven research was questioned by some of the engineers of the center.

> The Client being the most important, not upsetting him becomes the most important objective, not satisfying him. We brag about 'innovative products' that we don't even know whether we will be able to manufacture because we lack serious studies. We promise utopian deadlines not founded on objective assessment. We apply the 'project management' methodology (intelligent and efficient otherwise) to every single activity just to go faster. To go fast is fine, but to go where? (…)
>
> [the new organization] should not separate upstream synthesis from downstream application too much because a tree without roots has never yielded fruit (CRA Archives 6, p. 24).

Another report formulated this sentiment in even stronger terms:

> the strong demand for technical assistance stemming from the requirement for reactivity [towards the clients], sometimes created barely acceptable working conditions for researchers. The client is king, certainly, but serving him sometimes resembles slavery (CRA Archives 7).

Nevertheless, the new organization was to stay around for longer. Having been firmly established in 1995, it survived until 2005, outliving Rhône-Poulenc itself. In 1998, the group created a spin-off for all its

chemical activities: Rhodia. The CRA, along with a research center in Lyon (CRL), was at the heart of Rhodia's R&D structure. As for Rhône-Poulenc, it quickly sold the majority of its shares in Rhodia and in 1999 it merged with the German giant Hoechst to create one of the largest pharmaceutical companies in Europe, Aventis.

5. Building new identity: Aubervilliers under Rhodia and Solvay (1999–2020)

Rhodia was certainly one of the key players in the French chemical industry in the late 1990s and early 2000s, but the company suffered severe financial difficulties and, between 1998 and 2011, it lost almost half of its staff and factories.[3] The Rhodia crisis left a profound mark on the Aubervilliers research center. Some of its flagship activities, such as latex, were sold over the period. The future of the center itself was questioned in 1999 as some suggested it merge with the CRL in Lyon (Interview 4). These difficulties led very rapidly to two substantial changes that would affect the center's structure in the long run. Both concern a form of 'despatialization' or uprooting of the center.

First, in order to reduce the costs of new equipment, the physico-chemical characterization laboratory (the old physics laboratory) became in 2000 a shared 'laboratory without walls' between Aubervilliers and the research center in Lyon. Different sections of this laboratory were located on the two sites and the laboratory's manager had a substantial degree of autonomy. The overall goal was to create a common structure that would optimize the use of the resources on both sites without making any team feel disadvantaged (CRA Archives 8, Interview 4). The concept of 'laboratories without walls' spanned beyond the characterization laboratory, and some services, such as documentation, IT support, and technology and process unit, were also shared.

Second, when the center's survival was at stake in 1999, it was decided to build in Aubervilliers an impressive new building to reinvigorate the site. The new building, called Phenix, received more than 400 employees (let us recall that the center had around 500 workers for most of its existence). It was meant to host not the center's research

[3] Based on Rhodia activity reports from 1999 and 2011. See also Lebard and Ottenheimer 2008.

facilities or administration, but the administration of Rhodia's different business units and support functions (Interview 4). As such, it was not part of the CRA's research function (even though some units, such as intellectual property, closely collaborated with the scientists) and it remained independent from the CRA's director.

These two events – the establishment of laboratories without walls and the construction of the Phenix building – brought about a significant change in the way the CRA was conceived. The unity between the center as a research unit and the physical space where it was located was put in question. On Rhodia's Aubervilliers site, there were from this moment on organizations that were, strictly speaking, not part of the CRA. It is key to point out that these changes, while stemming from external circumstances (Rhodia's troubles and cuts), were introduced and implemented from the inside. The key protagonist in this turbulent evolution was the center's new director nominated in 1998, Suzanne Baumeige. She fought for the Phenix building and the laboratories without walls in order to keep the center alive and functional, as she believed that without these reforms the site itself would risk closing (Interview 4). In fact, this strategy should not be surprising considering that Baumeige was at the same time the director of the CRA and of Rhodia's division Rhodia Recherche, which coordinated the company's key assets in research and development. It was for her more than natural to think not in terms of individual sites and units, but in terms of the entire R&D activity. Laboratories without walls and the Phenix building were her initiatives to help the CRA in difficult times and reaffirm its position within the company.

And yet, it was perhaps this intervention in the way of thinking about the Aubervillers research center and its frontiers that led the company's directorship to take more interest in direct management of its R&D centers than its predecessors; a new direction that would slowly lead to another profound reorganization of Aubervilliers. In fact, from 1999, Rhodia's directorship more and more often used the expression 'European Research Pole' in its official communications instead of pointing out the existence of two separate research centers in Aubervilliers and in Lyon. As such, Rhodia was presented as having three such poles: one in the US in Cranbury, one in Brazil in Paulinia, and one in Europe on two sites (CRA Archives 9). While the rapprochement between Aubervilliers and Lyon was first established through a variety

of bottom-up collaborative projects and common utilities (laboratories without walls), it soon led to the formal integration of the two sites, this time as a top-down policy. From 2005, the two centers shared the same director, who was head of Rhodia's French (and later European) R&D structure. This structure was divided into two technological platforms: inorganic and specialty polymers (PMPS) in Aubervilliers and organic chemistry and materials (POM) in Lyon. These platforms replaced what were previously independent research centers. They continued to be accompanied by a number of shared services, such as the physical characterization laboratory. The PMPS in Aubervilliers was divided into two poles – formulation and coatings, and inorganic chemistry – that were themselves divided into departments corresponding to specific products. For example in the inorganic chemistry pole, there was a department for rare earths and another for silica. These departments were consequently divided into different laboratories, some of them focused on synthesis, others on applicability, others still on development. Without reproducing the entire complex organizational charts, let us have a look at the chain of command inside the CRA in 2006 (Figure 2).

This new architecture differed from that of 1995 on many levels. Strictly speaking, application laboratories were no more and the applicability laboratories lost their unique position, since all the laboratories were organized around product applications. At the same time, while the inorganic chemistry competence was back as a huge overarching theme, the coatings pole did not follow this logic. To put it simply, the new organization was not only more pyramidal, but also less fleshed out conceptually than that of 1995. As such, unlike the previous organizational charts, it had a more descriptive than prescriptive role. It was an attempt to describe what was still part of the CRA after the termination of many activities, reflecting different layers of organizational sediment accumulated over the years.

This organization was nevertheless short-lived. By 2008, Rhodia's R&D sector was completely reshaped once more. The most important change was the introduction of a strict separation between corporate R&D and business units R&D. Corporate R&D (or, more and more often, R&I) included a small range of transversal support laboratories on both sites such as the physical characterization laboratory. Business units' R&D was focused on end markets and included the vast majority of the laboratories in Aubervilliers and in Lyon. In other words,

from this moment on, there were two types of research conducted in Aubervilliers: market-related, hierarchically depending on Rhodia's business units, and corporate, depending on the general R&D director. The CRA as a unified entity was no more.

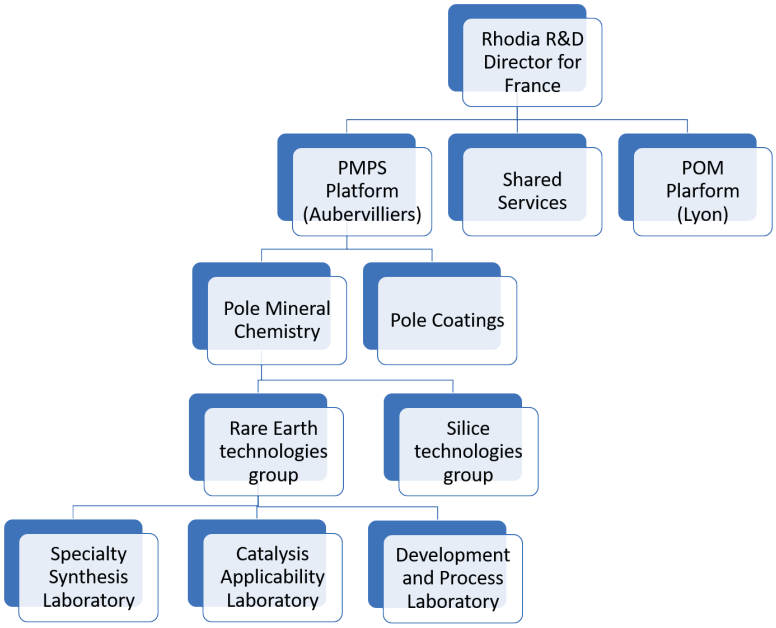

Figure 2. Example of R&D chain of command in Rhodia (2006)

In 2011, Rhodia was bought by Solvay, a Belgian chemical giant whose roots can be traced to the origins of the European chemical industry in the middle of the nineteenth century (Bertrams et al. 2013). Solvay's era was one of stability and, between 2011 and 2020, few substantial organizational changes were made. The most important one was the reintroduction of territoriality by reinstating regional directors of corporate R&I affairs in Aubervilliers and in Lyon in 2016. Figure 3 shows the make-up of the Paris site in early 2020.

We can see that there were four distinct structures on the site: 1) Global Business Units (GBU) R&I laboratories, whose research and innovation focus was on end markets and which reported to individual GBUs' R&I directors; 2) corporate science and technology R&I reporting to the center's director; 3) site management; and 4) R&I business support units

providing non-research-related services. All four had separate funding and some of them were part of independent hierarchies. Between 2008 and 2020, around 70–80 percent of the research staff worked for GBU laboratories, meaning that the vast majority of employees on the Aubervilliers site did not report to the site's director, but to the business units; a radical departure from the previous model in which the center's director was an intermediary between researchers and business units.

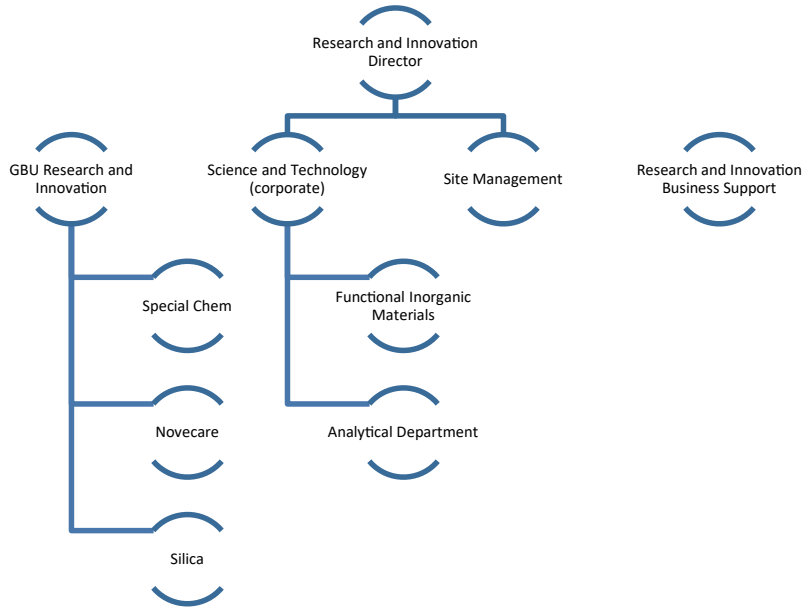

Figure 3. Organization of the Aubervilliers research site in 2020

In the middle of 2020, one important change took place in the research function. One of the GBUs, "Special Chem", decided to reorganize its R&I structure and closed its laboratories on the site. As a consequence, a significant part of the research staff was moved to the Functional Inorganic Materials laboratory. This was initially a little corporate unit created in 2010 to provide more long-term research. Today, it has become one of the center's largest laboratories, and the global balance between business and corporate research is closer to 60:40 (Interview 5).

What did the changes in the years 1999–2020 mean for the history of Aubervilliers as a research center? From 1953 to 2005, the CRA had

a single director responsible for both research and the management of human resources and of the site. While individual laboratories conducted research for different business units, the latter had to 'buy' the time of the laboratories, and the director was a mediator between the two, weighing the interests and priorities of the center. of course, business units wanted full control over the projects, but CRA was a multidivisional research center, meaning that it had a certain degree of autonomy in shaping its own long-term research strategy.

This relationship started to change in 1999 when the identification of the CRA with the site in Aubervilliers no longer held. In 2005, the CRA did not have its own director, and its different laboratories were integrated directly into the company's unified R&D structure. From 2008, the site and human resources were managed separately on the corporate level, and the vast majority of application laboratories were hierarchically subordinated directly to business units and did no longer report to the corporate R&D director. The remaining transversal laboratories shared their activities between Lyon and Aubervilliers. In other words, from 2008, the CRA did not have any structure of its own. What was described from that moment as the CRA was a bundle of different hierarchies and organizations brought together in a single physical space. This was nuanced by Solvay's decision to reintroduce the site director for R&I affairs in 2016 and by the extension of the corporate research in 2020. Overall, however, the Aubervilliers research center is substantially a different thing in 2020 from what it was even in the early 2000s.

6. Analysis and conclusions

Established in 1953, the CRA inherited its laboratories from different Pechiney facilities. This initial structure was surprisingly resilient. With minor modifications, it survived until the late 1980s. Then, the CRA's organization started to evolve more and more rapidly, with a major bottom-up-driven restructuring in 1994 that entirely reshaped the way research was conducted. Similar bottom-up initiatives were behind the redefinition of the place of the CRA in the company's overall research organization in the early 2000s. From 2005, however, the CRA slowly dissolved as an autonomous unit between competing hierarchies, this time due to the company's explicit top-down policies.

It is necessary to point out that throughout this study I have identified two levels of evolution that, while intertwined and interdependent, can be analyzed separately. I studied the organization of the research function of the center (Table 5), and the organization of the center as an overarching structure (Table 6).

Table 5. Organization of the research function

Years	Salient organizational features
1953–1975	Stable organization around big disciplines
1975–1988	Stable organization around big disciplines with a tendency towards specialization of laboratories.
1988–1994	Specialized narrower laboratories and first signs of market-driven research.
1995–2008	Attempt to balance market-driven research with broader transversal approach.
2008–2020	Market-driven research dominant.

Table 6. Organization of the center as an overarching structure

Years	Salient organizational features
1953–1999	Unitary pyramidal organization (research, site, employees under the same director).
1999–2005	Unitary pyramidal organization but 1) some shared laboratories between centers and 2) business units' administration present on site (research center vs site dichotomy).
2006–2008	Binary pyramidal organization between two sites (Aubervilliers, Lyon) + business units' and corporate administration on Aubervilliers site. No independent Aubervilliers director.
2008–2016	Non-pyramidal organization with separate hierarchies: 1) Business unit laboratories; 2) Corporate R&D laboratories; 3) Business units' and corporate administration; 4) Site and HR administration. No independent Aubervilliers director.
2016–2020	As above, but with a local director for corporate research.

In fact, the general architecture of the center remained stable for almost half a century. There was one director at the head of the Aubervilliers Research Center; he or she was responsible for the research

conducted on the site, for the staff, and for the site itself (including its extensions and the construction of new facilities). Between 1953 and 1999, it was exclusively the evolution of the center's scientific function that raised questions. Interestingly, the most drastic change in 1995 – the focus on final markets – took place when the center was still a unitary pyramidal organization with a clearly defined perimeter and a single director. However, the 1995 reorganization anticipated more general shifts that were to follow. The strict market focus of research became a new norm by the middle of the 2000s; the incorporation of the laboratories directly into business units, without the center's director as an intermediary, was a natural step in this evolution. This tendency was one of the factors that slowly brought about the dismantling of the unitary pyramidal organization of the center, which, step by step, gave up some of its core features to corporate: 1) control over the terrain; 2) control over the transversal laboratories (characterization, analysis); and 3) control over human resources; and to business units; 4) control over the scientific function (application, applicability, synthesis).

All the changes in the center's history can be framed with four overlapping tendencies: research specialization, market-driven logic, despatialization, and decentralization (Table 7).

Table 7. Broad tendencies in the evolution of CRA

1970s-1980s	Research specialization
1980s-1990s	Market-driven research
1990s-2000s	Despatialization
2000s-2010s	Decentralization

The first big tendency is **research specialization**. We should recall that up until the mid-1970s, the center's scientific function was divided along big disciplinary lines (inorganic, organic, polymer). of course, the actual problems that were studied inside them were much narrower. One could probably call the inorganic chemistry laboratory in the 1970s a rare earths/phosphates laboratory, as most of its sections worked on these topics; but what was put forward on the organizational level was the general competence in a given discipline. As already pointed out, these big overarching laboratories were 'competence pools' tapped by the company on a regular basis. If rare earths were a priority in the 1970s,

they had been completely absent in the inorganic chemistry laboratory in the 1950s. With their arrival, the directors might have created a separate unit or changed the name, but instead they simply attributed the topic to the existing structure and its engineers were expected to learn rare earths chemistry and organize themselves on their own to provide expertise in the field.

This attitude changed when the latex laboratory was established in 1975. One material was singled out due to its importance to the company. This was followed by another specialized laboratory in inorganic catalysis, and then, throughout the 1980s, the previously general disciplinary laboratories divided and took much more specialized names: materials, chemistry of solutions, radical polymerization, and so on. This improved transparency at the cost of adaptability. The CRA entered the 1990s with a number of narrowly defined fields of expertise.

But if specialization improved the clarity of scientific problems studied inside the center itself, it was lacking in terms of transparency toward clients. Here **market-driven research** comes into the picture, a new client-focused approach to industrial chemistry. It structured the CRA's activities in a way that made them directly relevant to final markets. This new approach generated difficulties, though. If research is to be entirely market-driven, is there still a place for multidivisional research centers such as the CRA? Should business units supervise research directly? The center's directors tried to counter the tendency, balancing its market-focused application laboratories with new core functions such as applicability laboratories, as well as with transversal services, such as physical analysis and characterization, that were to form the heart of the renewed CRA.

When Rhodia's troubles started in the late 1990s, the third tendency started to transform the CRA: **despatialization**. The center was no more identified with its own site because the site hosted business units' administration and laboratories 'without walls'. The space as a category became irrelevant as an element of the center's definition.

However, if the center is not about the spatial borders, its identity is called into question. The transversal services (such as the physico-chemical characterization laboratory) that had been at the core of the center in the 1990s, as opposed to more market-driven laboratories, themselves became detached from the center. With applicability laboratories gravitating toward end-market research, and the transversal

laboratories becoming shared between the centers, research naturally fitted into either business units or the general corporate function. The decentralized hierarchy replaced the pyramidal one.

This **decentralization** offers a different style of R&D management and of thinking in terms of what private R&D activity should look like. It is important to note that decentralization is not the same as disintegration, even though the center no longer exists as an administrative unit. In my previous studies, I showed that a research center could be a virtual institution made of different partially overlapping organizations, and yet its existence is not in doubt (Krasnodębski 2018). Which approach is more efficient: research centers as autonomous units with their own agenda, or research centers as bundles of organizational, spatial, and research trajectories that co-exist but respond to different hierarchies?

Leaving practical considerations apart, this paper opens up a range of questions concerning R&D management in a historical perspective. Did other similar centers evolve along similar lines? What are the consequences of these shifts for the broader history of science and technology? Or, more generally, can we establish a fully-fledged analytical framework to study and understand the evolution of private R&D in industrial chemistry in the last seventy years? Hopefully, further empirical studies will allow new perspectives to be opened on these issues.

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