CARTESIANISM AND CHYMISTRY

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Abstract. One of the most difficult, yet interesting change in the seventeenth-century natural philosophy was that of chemistry. This essay focuses upon Cartesian re-evaluation of the philosophical disciplines, arguing that, from a systematic perspective, chemistry cannot find a place in natural philosophy. Chemistry, in its seventeenth-century form of "chymistry" shares a number of common features with other traditions and practices. Descartes and his first-generation of followers discussed in this essay – Jacques du Roure, Robert Desgabets, and Jacques Rohault – will react precisely to this discipline of "chymistry," opposing it to their physics built on a combination between theory of matter and mechanical explanations. The very restrictive Cartesian theory of matter will come into tension with any intermediate explanatory entity, such as the chymical principles. This essay will investigate such tensions, arguing that they are caused by both ontological and epistemological commitments. For example, the principles of the chymists contradict the one material extension of the Cartesian world. At the same time, Cartesians require a more thorough reductive process then the one provided by chymical explanations. In this sense, chymistry is good for practical purposes, but fails in providing an explanation in natural philosophy and, hence, to represent a science.

Keywords: Descartes, chymistry, natural philosophy, Rohault, chymical principles, matter theory

Introduction

On April 15, 1630, Descartes confessed to Mersenne: "I am now studying chemistry and anatomy simultaneously; every day I learn something that I cannot find in any book."[1] It is a period when Descartes was interested in observations and experiments. He begun studying anatomy only recently, as his correspondence with Mersenne from December 18, 1629 testifies – "je veus commencer a estudier l'anatomie" – something which remained of a constant interest over his entire life.[2] His addition of chemistry to the study of anatomy reflects the disciplinary changes in the medicine of his time. Traditional Galenic medicine was in the process of transformation under the influence of Paracelsian views. The reform of medical

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practice – from Paracelsus to the mid-seventeenth century physicians – coincided with a new emphasis on experiment and observation. Thus, the preparation of curative medicines (*chymiatria*) was joined with anatomical observations and general medical practice. Allen Debus refers to this situation, in claiming that "by 1700 many of the most prestigious medical faculties of Europe had chairs either of chemistry or of Galenic *and* chemical pharmaceutical preparations."[3]

Chemistry was, thus, a needed tool for medical studies and the analogy between chemical analysis and medical anatomy became a common locus in the literature. For example, one can find such statement expressed in Nicaise Le Febvre's treatise:

> as the Anatomist doth make use of Rasors and other sharp Tools in his Dissections, to separate the better the several parts of the human body, which is his chief object: The same doth the Chymical Artist, fetching his instruction from Nature it self, to attain his end, which is nothing else but to joyn *homogeneal* and separate *heterogeneal* things by the means of Heat.[4]

The connection between chemists and physicians is a recurrent topic in the seventeenth century, where anatomy ("ana-tomy") and chemistry ("ana-lysis") were taken to represent the same activity of "cutting open" the bodies.[5] If dissection provides the anatomist with a straightforward view of how organs are disposed in the body, chemical analysis is supposed to reveal the hidden principles. However, the laboratory practice of "resolution" needed a background theory to explain the outcome of chemical process. This seemed to be achieved with Paracelsus' explanation in terms of three principles – salt, sulphur, and mercury.[6] The influence of this theory over the seventeenth-century thought can hardly be overestimated as it shaped many of the disciplinary debates of the period with an alternative view to the Aristotelian theory of four elements. Of a great interest for what follows is how Paracelsian *tria prima* and subsequent developments in seventeenth-century chemistry were discussed in the Cartesian philosophical context. However, my aim is not to explore the transformation of early modern alchemical and chemical practices and the theories generated by them, but to discuss the reaction of some self-identified Cartesian philosophers (not chemists) to the problem of chemical explanation in natural philosophy.[7]

Bernard Joly and Luc Peterschmitt have recently discussed the relation between Cartesian philosophy and chemistry.[8] Exploring the uneasy problem of how chemical phenomena are being treated by Descartes and some of his followers, Peterschmitt, but especially Joly, made it clear that answering the problem of the status of chemical objects within Cartesian natural philosophy is a pressing one. If both authors were mainly interested in reconstructing hidden chemical themes in Cartesian philosophy, I shall try in this essay to explore the problem from a different perspective. Thus, I shall attempt to address the problem of the disciplinary status of chemistry in the context of Cartesian philosophical system. For this, I shall rely

mainly on Descartes' classification of the philosophical disciplines in the *Principia philosophiae*, taking his natural philosophy to represent a system build on the theory of matter and mechanical explanations. As Steven Gaukroger has argued:

> Part II of the *Principia* deals with the foundational principles of Descartes' physical theory, which take the form of a synthesis of matter theory and mechanics. . . . Mechanics deals with physical processes in terms of the motions undergone by bodies and the nature of the forces responsible for these motions. Matter theory deals with how the physical behaviour of a body is determined by what it is made of, and in the seventeenth century it typically achieves this in a corpuscularian fashion, by investigating how the nature and arrangement of the constituent parts of a body determine its behaviour.[9]

However, Luc Peterschimtt expresses the clash between Cartesian mechanicism and chemistry, concluding that "Chemistry presents a problem for mechanism; indeed, chemistry turned mechanism into a problem, because chemistry is a limit for mechanism. . . . chemistry reveals that mechanism is a scientific ideology, extending concepts and models of explanation outside of their realm."[10] What were the philosophical reasons of Cartesians to reject chemistry? And even more important, what was the realm of chemistry at the discussed moment? Peterschmitt does not say; instead, he uses "chemistry" with reference to a well-established discipline that only later takes shape. Thus, his conclusion requires more investigation, due to the status of chemistry as a seventeenth-century discipline.

Established on new bases by Antoine-Laurent Lavoisier at the end of the eighteenth century, chemistry had a traditional culture of laboratory practice that was further supplemented with new theoretical developments.[11] A number of scholars investigated the fate of chemistry in the seventeenth century, revealing the intricate connections between medicine, alchemy, physics, and metallurgy.[12] Newman and Principe convincingly argued that seventeenth-century forms of chemistry should be described by the term "chymistry."[13] However, what is important to notice regarding this discipline is that in spite of this large variety in meanings, it was commonly described as an art dealing with the dissolution and composition of bodies. Such definition was under circulation up to 1694, when the first edition of the *Dictionnaire de l'Académie française* was issued and the term "chymie" was described as "the art of reducing the bodies to their constitutive principles by means of fire."[14]

In the French context, chymistry was practiced in the new scientific institutions of the Jardine du roi and the Académie des science. Practitioners, such as Christophe Glaser worked on "Les Mysteres de la Chymie," which covered pharmaceutical and alchemical themes. In fact, Glaser was very optimistic in stating that "ce bel Art" of chymistry is able to "see clear in all that is most hidden in Nature."[15] But there is something more than a good practice of chymical analysis

that is needed. Mi Gyung Kim stumbled upon the problem of the transformation of chemistry in the seventeenth century, arguing that what was required was "a new philosophical language, one less hermetical and more in tune with natural philosophy, rather than a disciplined practice, to become a 'science'."[16] However, adopting the language of natural philosophy is not a simple task and besides the change of taxonomy, it also implies a deeper transformation of the discipline. In my case study of early-Cartesian reaction to chymistry presented here, I shall point out how chymistry is analysed in terms of the type of explanation it can provide. From this perspective, the relation between chymistry and physics is the most important. Furthermore, by picking up Stephen Gaukroger's distinction between theory of matter and mechanics, I shall argue that the initial philosophical reaction of Cartesianism to chymistry mainly originated in the role ascribed to the matter theory.

Both mechanics and chymistry are very broad disciplines, suffering great transformations in the discussed period, which is why I shall try to keep a close focus on the systematic considerations about the two. Moreover, I shall restrain my analysis to a narrow time-frame (roughly between 1640s and 1670s) and to philosophers (Descartes and some of his first-generation followers), rather than chymists. Various scholars already discussed how Cartesian taxonomy is joined with seventeenth-century chymistry (e.g., Nicolas Lémery or Wilhelm Homberg) allowing for the establishment of a Cartesian chemical philosophy.[17] But this happens only later and with only one notable exception, Pierre-Sylvain Régis, the authors involved are all chymists. Hence, my approach draws attention to another problem, which should provide the study of such late Cartesians with a needed tool in furnishing an explanation of the disciplinary transformations of natural philosophy.

Descartes and chymistry

In his recent book on *Descartes et la chimie*, Bernard Joly remarks that one can find two types of Cartesian texts regarding chymistry: "on the one hand, those where he criticises the alchemists, their practices and doctrines, on the other hand, those where despite his hesitations, he deals with chemical objects."[18] Joly is mainly interested in the later, for which he finds support in various passages from *Les meteores* and the third and fourth parts of the *Principia philosophiae*. However, there is another type of text, where Descartes is interested in chymistry from a systematic perspective.

While various small references to "chymistry" can be found in Descartes' correspondence from the 1630s, a more direct approach is taken in 1644, when he published the *Principia* and in the correspondence of the year after this book has been printed. Thus, on July 7, 1645, Constantijn Huygens confessed to the French philosopher that he was "becoming more and more attracted to the anatomy of things." Something developed further in the letter, when he claims that:

> as far as the mechanical industry can extend on doing things, the chymical operations being the most obvious ways for taking advantage of this, it is a long time since I wanted to hear you speaking about these, to see in how little nomenclature you include so many waters, salts, oils, essences, spirits, and at least other superfluous chimerical differences that these good people present us in their laboratories.[19]

Huygens' request for a thorough description of the operations of chymistry reveals the connection with practice. The mystery of chymical operations seems to be at stake and Huygens expresses his belief that Descartes is able, not only to explain them, but also to achieve this with a very economic taxonomy. His enthusiasm about this topic is obvious and in the final part of the letter he invites Descartes to "spare some time in order to share" what he discovered about it.

Descartes' answer was not waited for long. Thus, on August 4, he replied:

> I've had trouble deciding to send you this letter without attaching any discourse involving chymistry, as you have expressed your desire; for there is nothing I would not willingly do in order to obey you, provided I was capable. But having already written all the little I knew on this matter, in the fourth part of my *Principles*, where I have discussed the nature of minerals and that of fire, and of all different effects that can almost be attributed to chymistry, it is impossible for me to write anything more, without risking myself to mistake, because I have not made the experiences which would have been necessary for me to come to the particular knowledge of each thing, and not being easy to perform them, I am renouncing to this study and to all the other similar ones, because I cannot complete them without help; and there are still plenty of other experiences I can solve without the help of others . . .[20]

What we can learn from this epistolary exchange is of a great importance for the topic of this essay. First, we can observe that both Descartes and Huygens understood chymistry in the way described above, as a sort of "anatomy of things." Second, Descartes suggests to his correspondent that he had already dealt with this issue in the fourth part of his *Principia*. And third, Descartes complains about the lack of possibilities in performing all the necessary experiments required to get a complete understanding of the chymical operations. However, despite the latter shortcomings, Descartes is confident in his prior explanation of the subject matter. But what does one discover about this topic, if looking at the last part of the *Principia*?

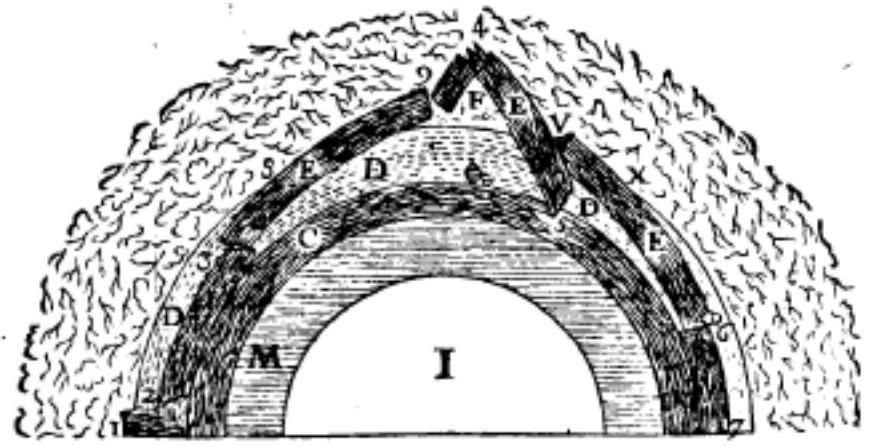

Figure 1: The formation of minerals in the bowels of the earth.[21]

The number of passages where Descartes deals with the principles of the chymists are not that many.[22] Yet, his views can easily be inferred from them. A direct discussion is made in the fourth part of the *Principia*, paragraph 63, where Descartes provides an explanation of how metals are produced in the mines. And he does this by reducing the chymical principles to mechanical ones:

> And I've explained here three types of bodies that seem to me to have a strong connection with those that chymists often take as their three principles, which they call salt, sulphur, and mercury. For we can take these corrosive juices for their salt; these small branches composing an oily matter for their sulphur, and quicksilver for their mercury. And my view is that the true cause for the production of metals in the mines is that these corrosive juices flowing here and there in the pores of the body C, are such that some of their parts are detached from others, which thereafter, being wrapped and as if covered by small branches of oily matter, are easily pushed from C to E by the parts of the quicksilver, when it is agitated and rarefied by heat. And accordingly to their various sizes and figures of these parts of the body C, they form different types of metals, which perhaps I should have had explained in more detail here, if I would have had the possibility of making all the experiences required to verify the arguments I have made on this subject.[23]

The mechanical explanation is similar to what Descartes said in various other places of his natural philosophy. What is however interesting in this passage is that Descartes goes beyond the regular chymical explanation, comparing the chymical principles to mechanical interactions between various aggregations of matter. If the resolutive process of revealing the principles is reduced to the physical

explanation in terms of hidden *mechanisms*, the principles of the chymists fall into Descartes' dissolving world of corpuscles. Just like any other body of his world, the *tria prima* is just an intermediary aggregation of matter that can be further divided and decomposed in terms of mechanical relations between smaller bodies.[24] This view on the status of chymistry is not singular. Descartes has already expressed it in a letter to Mersenne from July 30, 1640, where he reacted to Mersenne's description of a different set of three principles.[25] Showing some knowledge of the topic, Descartes explained the principles of the chymists in terms of different forms and arrangements of parts of matter. In fact, he accuses the chymists of reaching wrong conclusions because of their "fausse imagination."[26] Instead, his explanation makes appeal to the three 'elements' presented in his natural philosophy, which are nothing more than various arrangements of *res extensa*. Thus, 'elements' fill in the middle-ground between his theory of matter and the mechanical world of macroscopic bodies. This way, his move from the large, visible bodies, to their small, insensible constituents comes into tension with the chymical alternatives developed at that time.

However, the letter to Huygens discussed above confirms Descartes' indecision in providing a clear-cut rejection of the chymical principles. What seems to be required is an empirical refutation of chymistry, because theory – Descartes' theory of matter – makes the three chymical principles irrelevant for natural philosophy. Caught between practice and theoretical corpus of physics, this tension has further produced troubles to seventeenth-century Cartesians.

Cartesians and Chymistry

An early follower of Descartes, Jacques Du Roure published his *La Physique* in 1653. This is a book inspired by Descartes' natural philosophy, but at the same time, discussing other philosophical views. In his attempt to provide a complete textbook on physics, Du Roure addresses the problem of *the composition of bodies accordingly to the chymists* ("la composition des Corps suivant les Chimistes"). He begins with the general observation that "it is very difficult to define these Principles" and continues by listing the important contribution of chymistry to "Pharmacy, Medicine, and the Philosophical Stone."[27] Du Roure seems to be acquainted with new developments in chymistry, as he refers to Sennert, Severinus, Beguin, and Duchesne.[28] While the view expressed by Du Roure resembles other seventeenth-century claims about the usefulness of chymical practice in various aspects of life, he adds a critical comment about the possibility of chymistry as a science:

> [these principles] are not that general to explain the large number of bodies and of their effects . . . these Principles are difficult, obscure & by consequence useless in establishing a proper science. To understand that more clearly, one has to consider first, the uncertainty of their nature, of their qualities & of their number. . . . Secondly, one has to consider the

> infinity of species contained by these Principles. . . . Finally, one has to take into account the agreement claimed by the chymists [for their Principles] with the Elements & the Principles of Aristotle, the history of Genesis where they see that Moses does not discuss about Salt, Sulphur nor Mercury; at last, the Fables of the Poets in which after some dreams they think to have found the secrets of their Doctrine & of their Art.[29]

Du Roure's clear rejection of chymistry is not the only case we can find among Cartesians and it is in fact a turning point in the formulation of arguments against chymistry by a first generation of Cartesian natural philosophers. According to this passage, chymistry fails when it comes to its Principles. For du Roure, chymistry is a "Physique Resolutive," which should reveal the hidden constituents of bodies. Not its operations are questioned here – above, we have seen Du Roure praising it for the useful results – but its explanatory possibilities, especially when it comes to the elucidation of the structure of bodies. Theory of matter is the one questioned by Du Roure when he mentions the Aristotelian elements and chymical principles. While this opposition in terms of matter theory will produce other stirred debates, for the time being, the problem is more whether or not to call "chymistry" a science.[30]

Another follower of Descartes, Dom Robert Desgabets touches the same problem in his *Le guide de la raison naturelle* (c. 1671). While, he was more concerned with the problem of philosophical sects – especially with the relation between Cartesianism and Gassendism – Desgabets refers to the chymists. His words are revealing:

> As for the chymists, although one cannot blame nor despise their experiments, still has to accept that they do not treat philosophy by its first principles and they happily agree to be taken as servants, without claiming the glory that is reserved to the party leaders. I do not need to talk about Paracelsians, Fluddists, nor Helmontians, because their schools are only apt to receive the dregs of philosophy and make the meeting place for dreamers.[31]

For Desgabets, seventeenth-century chymistry cannot be a science, as it only deals with practice, not with the ultimately constituents of nature. In turn, dealing with the problem of the nature of matter is the domain of natural philosophy. Physics studies the matter theory that stays at the very basis of *science*. It reveals the ontological structure of the world, providing explanations of the phenomena discussed by natural philosophy.

By the same time when Desgabets was writing these harsh words against chymistry, another important Cartesian was printing his textbook on physics. After a few decades of experimental working, the Parisian Cartesian, Jacques Rohault, published in 1671 his *Traité de la physique*. In this very influential book, Rohault

spends some time to reject "the elements of the chymists."[32] The discussion follows after his remarks on the Aristotelian theory of elements, which is equally rejected:

> I cannot tell whether these or such Reasons, induced the *Chymists* to reject those Elements which the Antients would have introduced; thus much is certain, that they had proposed others very different. And in order to establish them; as they profess an Art which consists principally in using Fire after different manners, to separate as much as is possible, the different Parts of which different Bodies are composed, they have pretended, that this Resolution is the only Way to find out what are the true Elements which Nature makes use of in the Composition of Bodies; as the taking a Machine to Pieces, is the only way to find out what it is composed of.[33]

Besides the earlier attacks against chymistry – which we have discussed in the cases of Descartes, Du Roure, and Desgabets – Rohault adds here a methodological objection. His description of the method employed by the chymists – "this Resolution is the only Way to find out what are the true Elements which Nature makes use of in the Composition of Bodies" – already contains the reasons to reject it. In his view, if experiment and observation seems to lead to some states of matter (principles or elements), what chymists present as their principles cannot be properly described as such. A principle is not an empirical fact, but part of the theory. Rohault's scientific methodology, with its emphasis on both theory and experiment has a hypothetico-deductive structure. In science, experiment is not "the mere simple using our Senses," nor when one "deliberately and designedly make Tryal of any Thing, without knowing or foreseeing what will come to pass," but only when observations "are made in Consequence of some *Reasoning* in order to discover whether *it* was just or not."[34] We can infer from here that, for Rohault, the chymical operations fall under the second type of experimentation: they are examinations of the possible mixtures that constitute a body, yet, their so-called principles are not well founded.

Moreover, he reminds of du Roure's comments on the same topic: the resolutive method which uses fire will raise some problems when attempting to recreate a mixture that was split into its composing parts, making the two operations of chymistry not compatible one to the other. Besides, each of the Principles has various species, which means that, rigorously speaking, the number of chymical elements will increase. Resembling his comments on the "occult qualities" of the scholastics, Rohault claims that chymists hasten in giving names to things that are not well known.[35] Yet, he defends the chymical practice:

> I should think it a great piece of Injustice not to give the Chymists that Commendation which is due to their Industry and laborious Application. Without doubt the whole World, and the Philosophers particularly, are very much obliged to them for the Pains they have taken, and which they

> continue to take, to make a great Number of Experiments, whereby they come to the Knowledge of diverse Properties of many different Things.[36]

Rohault finds good reasons to rely on the results of the chymists, not only because they provide useful substances – especially in pharmacy – but also for revealing some of the hidden features of the natural world.[37] Thus, he continues the argument: "This gives them opportunity to find out and discover the Nature of Things, and at the same time, serves for a Rule to try the Truth of their Principles by, and to justify their Reasoning and the Consequences which they draw from thence. However, I think their manner of treating of Philosophy is not satisfactory, nor their *Elements* such as ought to be allowed."[38] Combining the appreciation of chymical practice with the disdain for their theoretical foundation, Rohault picks up the side of the natural philosopher: experiment and observation should be employed to test the hypotheses, but the entire theoretical corpus belongs to natural philosophy. Despite the alleged 'principles' of the chymists, Rohault does not allow them to interfere with the ontological commitments of physics. For him, matter should be explained only in terms of extension, to which one has to apply mechanical laws in order to grasp all natural phenomena.

At the same time, it should be noted that Cartesian natural philosophy postulates underlying causes for the observed phenomena. The effects of the visible interactions between bodies are explained in terms of hidden corpuscles. Rohault is aware of this difficulty when he claims that: "What good do those long and nice Disputes do, *about the Divisibility of Matter*? For though it could not be accurately determined, whether it be infinitely divisible or no; it would be sufficient to know, that it can be divided into Parts small enough to serve for all Purposes that can be."[39] Why not then accepting a chymical explanation in terms of three (or five) principles? As long as the principles of chymistry are conceived as mid-level ontological entities, mechanical division and chymical resolution look the same. Moreover, since the Cartesians largely adopted Descartes' view that bodies can be *indefinitely* divided, it is impossible to get a reduction all the way down to the ultimate constituents. In this sense, chymical elements can offer the same explanatory power as any corpuscular theory of elements. The problem is then how to observe these intermediary entities, not to mention that everything existing beyond them will stay hidden. As another Cartesian of the late seventeenth century, Bernard Lamy, has noticed: "One must recognize however that in a great many things, even with the aid of the *microscope, pneumatic machines and chemistry*, we still cannot penetrate what Nature had decided to conceal from us. We do not see what is inside. What can a physician do, therefore, except conjecture?"[40] No instrument can make the full reduction so that the structure of matter cannot be empirically grasped. Instead, a scientific method, similar with the one encountered in Rohault, will make the relation between theory – with its postulated entities – and observation, more meaningful.

Concluding remarks

My aim in this essay was to add another layer to the current debates about the relation between Cartesian philosophy and chymistry. If chymical phenomena and objects were studied in the recent scholarship, I have attempted to look at this relation from a disciplinary perspective. Thus, my interest was in the way in which Descartes, du Roure, Desgabets, and Rohault understood chymistry with respect to the system of natural philosophy. What is important in this sense is how Descartes and his followers changed the disciplinary boundaries of the traditional scholastic philosophy. As Gary Hatfield convincingly argued,

> Aristotelian physics was a general science of nature, subsuming not only the basic natural kinds, but also the subject-matters of what we might call physical astronomy, chemistry, biology, physiology, and psychology. (. . .) Descartes, then, regarded physics as a general science of nature, not as a discipline restricted to the analysis of body and the laws of motion, and his readers and followers understood the term in the same way.[41]

Natural philosophy (physics) becomes the exemplary science to which all the other disciplines are subordinated. Physical theories and practice take philosophical form. It is a process that will eventually happen with chymistry only that not in the context of the early Cartesianism represented here by Descartes and his first-generation followers. For the Cartesians discussed here, chymistry is still an Art (in the traditional sense), which means that its resolution is a real process, which ultimately destroys the body. Both du Roure and Rohault claimed that chymical practice fails when it comes to recreate the body that was split into its constitutive principles. For them, chymistry destroys its subject in the search for its (three) ultimate elements, which, after all, are various aggregations of the same *res extensa.*[42]

The cases of Cartesian philosophers, discussed here, are exemplary for this re-evaluation of natural philosophy under the form of mechanical philosophy. The clash between mechanics and chymistry reveals other important problems. On the one hand, the relation between theory and practice is once more discussed. Traditionally, alchemy and early modern chemistry were connected with preparation of medicines and transmutation attempts. In this sense, mechanics – which is not far from the science of engineering and craftsmanship – comes to represent the "pure" science of the two, on the basis of its reliance on the theoretical core of the natural philosophy. On the other hand, the clash between the two disciplines is relevant from the point of view of the type of explanation involved. Mechanics – in the form of Cartesianism – requires the existence of its stipulated invisible components of matter. Although chymistry seems to require a similar explanation, it fails short in providing one, just as we have seen in the passages from Du Roure and Rohault discussed above. In this sense, Luc Peterschmitt's conclusion – "chemistry presents a problem for mechanism; indeed, chemistry turned mechanism into a problem, because chemistry is a limit for mechanism" – is only partially true.[43] The conflict

between the two disciplines occurs in the final decades of the seventeenth century; mechanics and chemistry clashed in such a way that various authors were either trying to make chemistry more mechanical or to incorporate mechanics into chemistry.[44] However, at the time when Descartes and a first generation of Cartesians were writing their philosophical corpus, chemistry could not represent a limit for mechanism as it was still "chymistry," a discipline under development. On the contrary, mechanical explanation seemed to cover all the phenomena and everything needed was an account in terms of motion of corpuscles. Robert Boyle reached a similar conclusion in his *Origin of Forms and Qualities*:

> And though the Unsatisfactoriness and Barrennesse of the School Philosophy have perswaded a great many Learned Men, especially Physicians, to substitute the Chymists Three principles, instead of those of the Schools; and though I have a very good opinion of Chymistry it self, as 'tis a Practicall Art; yet as 'tis by Chymists pretended to containe a Systeme of Theoricall Principles of Philosophy, I fear it will afford but very little satisfaction to a severe enquirer, into the Nature of Qualities. For besides that, as we shall more particularly see anon, there are Many Qualities, which cannot with any probability be deduc'd from Any of the three Principles; those that are ascrib'd to One, or other of them, cannot Intelligibly be explicated, without *recourse to the more Comprehensive Principles of the Corpuscularian Philosophy*. To tell us, for instance, that all Solidity proceeds from Salt, onely informing us, (where it can plausibly be pretended) in what materiall principle or ingredient that Quality resides, not how it is produced; for this doth not teach us, (for example) how Water even in exactly clos'd vessels comes to be frozen into Ice; that is, turn'd from a fluid to a Solid Body, without the accession of a saline ingredient.[45]

Even if this passage refers mainly to the problems found by physicians in their application of Aristotelian theory of elements and their attempt to replace it with chymical principles, it sheds light for the way in which corpuscular philosophy is viewed. For Boyle – as for all the Cartesians discussed above – only the later can provide such general principles to reveal the secrets of nature. The rest fails to make the passage from art to science.

From the point of view of the history and philosophy of science, we can conclude that the episode of scientific transformation discussed here provides insights into the debates concerning the ontology and epistemology that shaped the formation of modern science. The theory of matter advocated by natural philosophy clashes with the *tria prima* of the chymists. The new emphasis on experiment one can find in the seventeenth century fails short in deciding between mechanics and chymistry, as both of them are conceived to deal with "the anatomy of things." However, the open rejection of chymistry in the works of Cartesians points out one of the important features in the constitution of modern science. Our scientific

model of explanation is built upon the one produced by Descartes and his followers. Ontological and epistemological commitments are linked together in a coherent whole, combining the use of hypotheses, experimentation, and, from one moment onward, mathematization. Thus, chymistry had to transform itself into chemistry in order to be recognized as a science.

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[2] For Descartes' letter to Mersenne from December 18, 1629, see AT I, 102. For Descartes' interest in the study of anatomy, see his letter to Mersenne from November 13, 1639 (AT II, 621).

[3] See Debus, A. G., "Chemists, Physicians, and Changing Perspectives on the Scientific Revolution", *Isis* 89 (1998): 77. For a discussion of the relation between chemical-medicine and natural philosophy in England, see Anstey, P., "The Matter of Medicine. New Medical Matter Theories in Mid-Seventeenth-Century England" in *Vanishing Matter and the Laws of Motion. Descartes and Beyond*, eds. D. Jalobeanu & P. Anstey (London: Routledge, 2011), 61-79.

[4] See Le Febvre, N., *A Compleat Body of Chymistry* (London, 1664), 19, quoted in Newman, W., "The Chemical Revolution and its Chymical Antecedents (Review Essay)", *Early Science and Medicine* 13 (2008): 179.

[5] It is interesting to notice the common use of the figure of Democritus, who was considered both the father of anatomy and of chemistry. Moreover, Democritus, the atomist, was an equally important figure for seventeenth-century theories of matter. For a thorough discussion of the image of Democritus in the early modern period, see Lüthy, C., "The Fourfold of Democritus on the Stage of Early Modern Science", *Isis* 91 (2000): 443-479.

[6] See Debus, A. G., *The French Paracelsians: The Chemical Challenge to Medical and Scientific Tradition in Early Modern France* (Cambridge: Cambridge University Press, 1991).

[7] For some studies of the relation between alchemy, chemistry, and theories of matter in the seventeenth century, see Clericuzio, A., *Elements, Principles, and Corpuscles. A Study of Atomism and Chemistry in the Seventeenth Century* (Dordrecht: Kluwer Academic Publishers, 2000) and Lüthy, C., Murdoch, J. and Newman, W., (eds.), *Late Medieval and Early Modern Corpuscular Matter Theories* (Leiden: Brill, 2001).

[8] See Joly, B., *Descartes et la chimie* (Paris: Vrin, 2011) and Peterschmitt, L., "The Cartesians and Chemistry. Cordemoy, Rohault, Régis", in *Chymists and chymistry: studies in the history of alchemy and early modern chemistry*, ed. L. Principe (Sagamore Beach, MA: Science History Publications, 2007), 193-201.
[9] Gaukroger, S., *Descartes' system of natural philosophy* (Cambridge: Cambridge University Press, 2002), 93-94.
[10] See Peterschmitt, L., (2007), 201.
[11] For the evolution of chemistry in the seventeenth and eighteenth centuries, see Kim, M. G., *Affinity, that elusive dream. A genealogy of the Chemical Revolution* (Cambridge, Massachusetts: MIT Press, 2003).
[12] See Newman, W., "From Alchemy to Chymistry", in *The Cambridge History of Science. Vol. 3: Early Modern Science*, eds. K. Park & L. Daston (New York: Cambridge University Press, 2008), 497-517; Principe, L., ed., *Chymists and chymistry: studies in the history of alchemy and early modern chemistry* (Sagamore Beach, MA: Science History Publications, 2007); Newman, W., & Grafton, A., eds., *Secrets of Nature. Astrology and Alchemy in Early Modern Europe* (Cambridge, Massachusetts: MIT Press, 2001); Debus, A., (1998).
[13] See Newman, W. & Principe, L., "Alchemy vs. Chemistry: the etymological origins of a historiographic mistake", *Early Science and Medicine* 3 (1998): 32-65. A similar view is expressed in Joly, B., "Chimie et mécanisme dans la nouvelle Académie royale des sciences: les débats entre Louis Lémery et Etienne-François Geoffroy", *Methodos* 8 (2008).
[14] See *Le dictionnaire de l'Académie françoise* (Paris: J. Coignard, 1694), vol.1, 189: "Art de resoudre les corps en leurs principes par le moyen du feu."
[15] Glaser, C., *Traité de la chymie* (Paris, 1672), unpaginated preface: "voit clair dans tout ce que la Nature a des plus cache."
[16] Kim, M. G., (2003), 4.
[17] See for example Mouy, P., *Le Développment de la physique cartésienne: 1646-1712* (Paris: J. Vrin, 1934), 175 and Joly, B., (2011), 175-217.
[18] Joly, B., (2011), 59: "d'une part ceux où il critique les alchimistes, leurs pratiques et les doctrines, d'autre part ceux où, malgré ses réticences, il traite des objets de la chimie."
[19] The entire passage is: "Si vous me permettez, Monsieur, de tourner ce feuillet, j'ajouterai que, depuis votre Philosophie aucunement comprise, *je deviens de plus en plus amoureux de l'anatomie des choses*. Et *pour autant que l'industrie mécanique y peut aller, les opérations chimiques étant les plus apparents moyens d'en tirer de l'avantage effectif, il y a longtemps que je brûle d'envie de vous en entendre discourir, pour voir en combien peu de nomenclature vous comprenez tant d'eaux, de sels, d'huiles, d'essences, d'esprits, de magistères et autres différences chimériques au moins superflues, que ces bonnes gens nous installent en leurs laboratoires*" (AT IV, 243-244).
[20] "J'ai eu de la peine à me résoudre de vous envoyer cette lettre, sans y joindre quelque discours touchant la chimie, ainsi que vous avez témoigné le désirer; car il n'y a rien que je ne fisse très volontiers pour vous obéir, pourvu que j'en fusse capable. Mais, ayant déjà écrit tout le peu que je savais touchant cette matière, en la quatrième partie de mes Principes, lorsque j'y ai traité de la nature des minéraux et de celle du feu, et de tous les divers effets auxquels se peut quasi rapporter toute la chimie, il ne m'est pas possible d'en rien écrire davantage, sans me mettre en hasard de me méprendre, à cause que je n'ai point fait les expériences qui m'auraient été nécessaires pour venir à la connaissance particulière de chaque chose; et n'ayant point la commodité de les faire, je renonce dorénavant à cette étude et à toutes les autres semblables, touchant lesquelles je ne pourrais entièrement me satisfaire sans

l'aide d'autrui; car il m'en reste encore assez d'autres, auxquelles je n'ai besoin que de moi seul, pour occuper agréablement le reste de ma vie" (AT IV, 260-261).

[21] See Descartes, R., *Principia philosophiae* (Amsterdam: Elsevier, 1644), 226.

[22] For a detailed discussion of Descartes' treatment of chymistry in the *Principia* IV, see Joly, B., (2011).

[23] "63. Des principes de la chimie, et de quelle façon les métaux viennent dans les mines. Et j'ai ici expliqué trois sortes de corps qui me semblent avoir beaucoup de rapport avec ceux que les chimistes ont coutume de prendre pour leurs trois principes, et qu'ils nomment le sel, le soufre et le mercure. Car on peut prendre ces sucs corrosifs pour leur sel, ces petites branches qui composent une matière huileuse pour leur souffre, et le vif argent pour leur mercure. Et mon opinion est, que la vraie cause qui fait que les métaux viennent dans les mines, est que ces sucs corrosifs, coulant çà et là dans les pores du corps C, font que quelques-unes de ses parties se détachent des autres, lesquelles par après, se trouvant enveloppées et comme revêtues des petites branches de la matière huileuse, sont facilement poussées de C vers E par les parties de l'argent vif, lorsqu'il est agité et raréfié par la chaleur. Et selon les diverses grandeurs et figures qu'ont ces parties du corps C, elles composent diverses espèces de métaux, lesquelles j'aurais peut-être ici plus particulièrement expliquées, si j'avais eu commodité de faire toutes les expériences qui sont requises pour vérifier les raisonnements que j'ai faits sur ce sujet" (AT IXb, 235-236).

[24] For the various problems induced by Descartes' view concerning the essence of matter, see Dobre, M., "The Vanishing Nature of Body in Descartes's Natural Philosophy", in *Vanishing Matter and the Laws of Motion. Descartes and Beyond*, eds. D. Jalobeanu & P. Anstey (2011), 11-30.

[25] See AT III, 130-131. For a more detailed discussion of Descartes' reference to "principles" and the use of "elements," see Joly, B., (2011), 86-98.

[26] See AT III, 130-131.

[27] See Du Roure, J., *La Physique*, Art. 4 LI-LII (Paris,1653), 41-43.

[28] Besides these names, in his *Dessein d'une institution universelle*, du Roure gives a slightly different list of authors one should consult in the study of chymistry: "Pour la Chimie, Crollius, Beguin, Declave, Davissone, Glauber & Barlet. C'est par les principes de cet Art que Paracelse, Quercetan, Fabri, & Helmont ont taché d'expliquer la Medecine à laquelle servent les Auteurs qui traitent ou des Plantes comme Dioscoride, Theophraste, Mathiole, & Bauhin: ou des Metaux comme Agricola, Caesius, le Cosmopolite, & quelques autres Auteurs que le Theatre Chimique contient: ou des Animaux comme Aristote, Aldovrandus: ou enfin de toute la nature comme Pline." See Du Roure, J., *Dessein d'une institution universelle: grammaire générale, nouveaux rudimens et nouvelles règles de la langue latine* (Paris, 1661), 6-7.

[29] Du Roure, J., (1653), 41-43: "Il ne sont pas assez generaux pour expliquer le divers nombre des corps & de leurs effets . . . ces Princies sont dificiles, obscurs & consequemment inutiles à établir une veritable science. Pour entendre cela plus clairement il faut en premier lieu considerer l'incertitude de leur nature, de leurs qualitez & de leur nombre. . . Secondement il faut considerer l'infinité des especes que ces Principes contiennent. . . En dernier lieu il faut considerer l'acord que les Chimistes en pretendent faire aveq les Elements & les Principes d'Aristote, Aveq l'histoire de la Genese où ils voyent que Moyse ne parle ny du Sel ny du Soufre ny du Mercure: Enfin aveq les Fables des Poëtes dens léqueles apres plusieurs reveries ils pensent avoir trouvé les secrets de laur Doctrine & de leur Art."

[30] For later debates about the status of chymistry in the context of French Cartesianism, see Joly, B., (2008).

[31] See Desgabetes, D.R., *Oeuvres philosophiques inédites* IV: "La guide de la raison naturelle," Ch. 4 (Amsterdam: Quadratures, 1983-1985), 116(29-33), [e.81r-82v]: "Car pour les chimistes, quoiqu'on ne puisse blamer, ni mépriser leurs experiences, on est d'accord qu'ils ne traitent pas la philosophie par ses premiers principes et qu'ils doivent se contenter de passer pour des gens de service, sans pretender à la gloire qui est due aux chefs de partis. Je n'ai que faire de parler des Paracelcistes, des Fluddistes, ni des Helmontistes, parce que leur école n'est proper que pour recevoir la lie de la philosophie et pour être le rendez-vous des visionnaires."

[32] See Rohault, J., *System of Natural Philosophy, Illustrated with Dr. Samuel Clarke's Notes, taken mostly out of Sir Isaac Newton's philosophy* (New York: Garland Publishing, 1987), vol.I, Part1, Ch. XX 1.

[33] Rohault, J., (1987), vol. I, Part I, Ch. XX 1, 108.

[34] Rohault, J., (1987), unpaginated preface.

[35] See for example Rohault, J., (1987), vol. I, Ch. XX 10, 110: "their Science extends no further than to give Names to things whose Natures they understand not."

[36] Rohault, J., (1987), vol. I, Part I, Ch. XX 6, 109.

[37] In a similar manner, Christoph Glaser will claim that chymistry "est la clef capable d'ouvrir aux Physiciens la porte des secrets naturels, en reduisant toutes choses dans leurs principes." See Glase, C., (1672), 3-4.

[38] Rohault, J., (1987), vol. I, Part I, Ch. XX, 109.

[39] Rohault, J., (1987), unpaginated preface. This passage is remarkably similar with Robert Boyle's claim that Descartes and the atomists are saying the same things and all of them are describing corpuscles in motion.

[40] Lamy, B., *Entretiens sur les sciences* (Paris, 1683), 259 (emphasis added); quoted in Clarke, D., *Occult Powers and Hypotheses* (Oxford: Oxford University Press, 1989), 175.

[41] Hatfield, G., "Review Essay: The Importance of the History of Science for Philosophy in General", *Synthese* 106 (1996): 113-138; 118.

[42] Note here that this is the point of view of the Cartesian philosophers. Since chymical analysis is considered to dissolve the temporary bond between elements, most of the seventeenth-century chymists would have argued for the reversibility of the process: the initial body can be recreated.

[43] See Peterschmitt, (2007), 201.

[44] See Joly, B., (2008) and Kim, M. G., (2003).

[45] Boyle, R., *The Works of Robert Boyle. Vol. 5*, eds. M. Hunter & E. Davis (London: Pickering & Chatto, 2000), 301 (emphasis added).