Eighteenth Century Chemistry: Between Natural Philosophy Without Nature and Physics Without Reason

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The aim of this paper is to show that, in 18th century Chemistry, at least in French Chemistry, there was nothing anymore but an instance of reality to consider, the existence of bodies itself. Chemistry gave up the idea of Principles, of a Reason or of a Nature transcending all the chemical phenomena, which prevailed hitherto in this science, without necessarily taking refuge in another system supposing an inaccessible reality; the only existing reality is that which appeared in laboratory. In this direction, without real base hidden behind tangible appearances, therefore without Nature, Chemistry abandoned natural Philosophy by definition. Chemistry's works fitted in at that moment with 'tragic processes' consisting in refusing any 'metaphysical' argument from any thought system to practise a clearly experimental physics,[1] or rather something which sounds like an oxymoron, a 'physics of artifice'; the artifice would not be anymore a continued Nature since, for chemists, Nature was henceforth defined as continued artifice. Without any order in Nature, Chemistry felts free to push back its boundaries and so chemical theory and practice find their "application to Physics, natural History, Medicine & animal Economy" to repeat the second part of Macquer's title in 1766 to *Dictionnaire de Chimie,*[2] and as one can see in the *Encyclopédie* of Diderot and d'Alembert.[3] Certainly 18th century Chemistry still seems to declare itself as a part of natural Philosophy and Physics. However, at the very beginning of the century, Wilhelm Homberg openly claimed a practice which was not simple Physics, but precisely, "chemical Physics".[4] The way, in the *Système des Connaissances Humaines* at the beginning of the first volume of the *Encyclopédie*, which leads from a Knowledge Tree trunk to Chemistry, was not rightly followed by Gabriel-François Venel in his article "Chymie" in the third volume: Chemistry was not either for him simple Physics or as he named it "ordinary Physics".[5] Chemistry was distinguished clearly by its studies on the world's small body phenomena; but if ordinary Physics tried to explain this world, Venel warned "all there will be badly".[6] This concern of distinguishing Chemistry like particular

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Physics, like particular natural Philosophy, was neither exclusively justified by its characteristic experimental dimension, neither by its interest for phenomena whose cause is invisible. From a chimico-chemical point of view, it was not the sign of a rupture either between Alchemy and Chemistry. This distinction stems rather from a new way of looking at bodies, starting with the search for an order –not natural– but artificial one. Chemists had opted for a world without nature, without metaphysical reason, without invisible reality hidden behind the palpable one; a world in which they approved unconditionally the existence of chemical bodies and facts, and not anymore a world in which they accepted their existence provided that there was any theoretical explanation. Eighteenth-century chemists place themselves within a world they absolutely didn't know. They gradually gave up their naturalist representations, while settling in artificialist ones. Adopting a tragic point of view on the matter probably gave them more self-confidence or even certain superiority in the field of natural sciences. Their work was not been curbed anymore by alleged natural materials they could only purify or damage or imitate, in other words they could only undo and redo what nature did; now their productions were their own creations: they were able to make by their own. Chemists gave up any *a priori* intellectual command of matter. This renunciation could look like a kind of humility when faced with the matter which was hard to know. So Homberg did not think to isolate true principles of mixts anymore (inaccessible anyway in their pure forms), but he only wanted to set apart some indecomposable and perfectly tangible substances from the last resolution of mixts. As for Venel, he claimed the right to work in "vagueness" and "approximation",[7] and out of any system (for him, "Cartesian, corpuscular, Newtonian, academic or experimental" systems), even if he admited that, in the history of Chemistry, systems played a role in the formation of Chemistry as a science.[8] However this humility did not mean chemists gave up the hope of any progress in Chemistry, but it only expressed their 'artificialist' posture, in opposition to the naturalist posture which was current in Chemistry hitherto. But chemists were far from being pure empiricists. They fully accepted the complication of the world of substances they tried to order, after the simplicity of the former world of Chemistry of Principles become chaotic.[9] Vagueness and approximation would become a scientific practice for Venel, "a specific right" (*un droit particulier*) of Chemists who have "their own & independent manner" (*leur manière propre & indépendante*); what it was about here was their "boldness" (*hardiesse*) ("one said the madness" (*on a dit la folie*), Venel writes), "Chemists' enthusiasm" which "can give rise to genius" (*qui peut prêter au genie*).[10]

The idea of Nature in Chemistry was suggesting, not only a natural foundation for the chemical compounds –in other words being behind the appearance–, but an order which transcended the disorder and the diversity of chemical substances. In the absence of a metaphysical postulate, or a Reason of things, 18th century chemists, like Homberg, or Geoffroy with his famous affinity table, or Rouelle with his neutral salt table, tried to gather chemical facts and bodies in wholes which made sense. With 1702 Homberg's Chemistry definition, matter took on the form of simple bodies still identified like principles, and ceased being a constraint in Chemistry's practice; knowledge of matter was not certain, neither was it a precondition. It was not anymore necessary for these principles to be themselves principles; it was enough that they were principles for the chemist in his relation with experiment. The "undisputed truth" (*la vérité certaine*) was related, for Homberg, with the immediately verifiable existence of bodies in laboratory. So that substances called salt, mercury, sulphur, water and earth were not anymore, as they were in the former century, instances of true principles of same names. Salt, mercury, sulphur, water and earth represented mainly, in the truth of their existence, some genera of bodies containing several species. For example, the genus salt was the genus of soluble and sapid substances, and contained the following species, acid salts, "salts which smell like urine" and alkaline salts, to which Homberg added another species, the essential salts, obtained by extraction, then crystallisation.[11] Therefore Chemistry was organised according to a new order, and not anymore according to an order following the triple nature of the production and conservation force sometimes called universal Spirit or universal Nature.[12] The very start of 18th century corresponded to a multiplication of the number of substances: after Salt Chemistry in 17th century for example, the "chemistry of the salts is the great affair" of the next century, according to Jean-Jacques Rousseau.[13]

In the first decades of 18th century, chemical bodies tended thus to take their place in a new general plan of all substances. Chemical experiments didn't really focus on a single subject, but on a species or a genus, as one can see, for instance, with Homberg's studies on the force of acid salts and alkali salts in 1699 and 1700, and on volatile salts of plants in 1701.[14] It was specially the case in 1718 with Etienne-François Geoffroy's "table des différents rapports observés entre différentes substances".[15] Taxonomy and nomenclature in Chemistry become real methods of knowledge. The absence of a transcendent order after the disappearance of the idea of Nature was offset by the classification and a certain nominalism. Chemists probably gave a name or classified more to know, than to recognise.[16] Geoffroy's table summed up approximately 75 possibilities of combinations of classified bodies according to a relative order of binding tendency in relation to the body at the top of each column. Geoffroy did not contend himself with summarising the behaviours of the 19 substances contained in the table, but gathered some of them in 4 species in order to expose their general behaviours (these species were the acid liquors, salts, metals and the absorbing earth). According to Geoffroy, the table required only to be supplemented with additional experiments in order to identify other affinities.[17] The lack of theoretical explanations about the various phenomena of selective substance displacements shown in the table (in 1718 Geoffroy's memoir as well as in his 1720 memoir on the same subject[18]) must have disconcerted the French Academicians at the time. Fontenelle, the perpetual secretary of the Academy, most probably suspected a Newtonian reason to explain them, since he was the first to translate Geoffroy's word "*rapport*" by "attraction".[19] However in the review he gave on the table, he wrote that it is to be regretted that there is no reason to justify the various binding suitabilities between bodies observed in laboratory; he said: "[…] But from what active principle can one understand this more [or less] suitability?" *("[…] Mais quel principe d'action peut-on concevoir dans ce plus [ou moins] de convenance ?*").[20] A few chemists initially tried to put forward some reasons for these affinities (e.g. Stahlian reasons for Gilles Boulduc, Cartesian ones for Louis Lemery[21]) before accepting the table for what it was:[22] The table just revealed a very useful order to establish operational strategies in Chemistry and to deduce the mechanism from confusing operations; and that "whatever the [active] principle may be", as Fontenelle rather disconcertingly notes it.[23] Geoffroy was indeed neither a Newtonian nor a Stahlian chemist but a chemist in close touch with his time; a chemist whose way of practicing Chemistry fully showed an artificialist approach. Therefore it is not needed to postulate any theoretical structure for the substances of the table, it was enough to contemplate this table; the reason is in the table and not in the bodies. Knowledge of a particular natural body was then substituted by artificial knowledge of the place of this body in a particular table's column. But it is to be noticed that Geoffroy did not speak of a law, even less a natural law, but quite simply of a "rule" in the chemical behaviours which he reported.[24] Indeed, what his table was about was not an external power (like subtle matter, or Newtonian attraction) which would drive bodies to be combined or to be separated. Affinities were what made combinations possible and not what caused them. In this artificialist approach, affinities in Chemistry were always considered just like laboratory results; in contrast a naturalist approach just considered the antecedents. In other words, chemical affinities were related to some circumstances in laboratory and not to the essence of bodies; they just referred to the possibility for elements to unite. Certain combinations happen to occur, others did not: Geoffroy's affinities did not refer anything else than this shared possibility to unite.[25] Chemical affinities were not used differently by chemists till the middle of the century;[26] hence the incomprehension of Buffon who wished to subsume all these phenomena under a mathematical expression based on Newton's law attraction.[27] His incomprehension was not on the doctrine, Buffon is very well informed about Chemistry, but on the way of thinking about the chemical phenomena of the artificialist Chemistry which used no metaphysical postulate. He wrote: "The darkness of Chemistry is mainly due to the fact that one not much generalized its principles, & because one did not join them together with those of the high Physics. Chemists adopted affinities without understanding them, i.e. without understanding the relation between the cause and the effect which is nevertheless not other than that of the universal attraction" ("*L'obscurité de la chimie vient en grande partie de ce qu'on en a peu généralisé les principes, & qu'on ne les a pas réunis à ceux de la haute physique. Les chimistes ont adopté les affinités sans les comprendre, c'est-à-dire sans entendre le rapport de la cause à l'effet qui, néanmoins n'est autre que celui de l'attraction universelle*").[28] However, affinities according to Venel, could only be a relative property of a heterogeneous matter.

The result of element combinations in the left part of Geoffroy's table was the subject of a new research on an artificial classification. This part related to the saline bodies, acid salts and alkali salts, which combined and formed mixts called "neutral salts". In 1743, Guillaume-François Rouelle suggested in a communication published in the volume for 1744 of *Mémoires de l'Académie Royale des Sciences*, a table of neutral salts according to their external crystalline shapes, and also according to the degree of heat and the way they crystallised. The memoir's title was very significant besides: "Memoir on neutral salts, in which one suggests a methodical division of these salts, which facilitates the means to reach the theory of their crystallisation" ("*Mémoire sur les sels neutres, dans lequel on propose une division méthodique de ces sels, qui facilite les moyens pour parvenir à la théorie de leur crystallisation*").[29] Actually, this study was very far from a naturalist study of the crystallisation phenomena, but it was carried out with the hope to produce a theory of crystallisation by using nominalism and arbitrary taxonomy. Neutral salts did not relate back to natural reality, but to a subjective definition also containing some well defined categories of substances: "I call […] neutral salt, any salt formed by the combination of any acid, either mineral or vegetable, with a fixed alkali, a volatile alkali, an absorbing earth, a metal substance, or an oil".[30] Neutral salts gather, according to the expression of Rouelle, in "families" or "classes", because of their common shapes and properties, and not according to a similarity of nature; they can undergo a "methodical division" by regarding closely "the only phenomena of crystallization". The reasons of the neutral salts' dissolution and of their crystallisation were unknown for Rouelle; he only noted that the opinions on those subjects are divided. He just observed that the parts of salts group together into crystals, what he called "the first law of crystallisation".

Rouelle defined three degrees of heat, each one divisible into three others,[31] in order to distribute neutral salts into six sections made up of four genera, which contained several neutral salt species; the last section being more or less that of the saline bodies that were unclassifiable elsewhere. The well known neutral salt species which existed in nature had already a chemical symbol to be represented, according to an algebraic model, linking the symbol of the acid with the symbol of the base using the sign "+" he calls "the small cross". Rouelle also suggested in 1754 a completely different neutral salt taxonomy, but still with an artificialist mind.[32] Rouelle's work will not be detailed further,[33] however it must be emphasised that a neutral salt was really a chemical concept at this date in history. Later Buffon estimated that the number of possible combinations between acids and bases was 474; in other words, there were 474 possible neutral salts.[34] Lavoisier, after having identified new acids and new salifiable bases, raised this number to 1152 possible neutral salts.[35] The substances about which they talked did not correspond to materials observed in laboratories or elsewhere. Rather, for the most of part, they corresponded to beings to be created, as they already belonged to a world established by artificialist reason; once they are obtained by the chemist, they become, in the words of Bachelard, "concepts which have been attained" (*des concepts realisés*).[36] To a certain extent, can one say from then on that these saline bodies were natural? Chemists left the realms of actual reality for the realms of possibility. So, not only the real did not reach all the possibility, but the very possibility of Nature was far from being able to compete with the chemists' possibilities. Artificialist Chemistry clearly went beyond the framework of naturalist Chemistry, and that occurred a hundred years earlier than Bachelard thought.[37]

Space does not permit to discuss the great mechanical philosophers' interest in Chemistry, which was partly due to its 'artificialism'. Nor about chrysopoetic works, as pure artificial productions for Geoffroy, Du Fay, Grosse, and Hellot. In the first half of 18th century Chrysopoeia became a thought of the present time, i.e. of what actually exists, and not a thought of past time, with its attempts to rediscover the elusive truth of Principles, as Malouin explained in his article "Alchimie" in the *Encyclopédie.*[38] Unfortunately neither is it possible to comment on Venel's position on Chemistry;[39] Chemistry was according to him completely independent from ordinary Physics because of the absence of any metaphysical postulate. For him, the last two centuries Chemistry were "rich in facts, and in real chemical knowledge" (i.e. experimental) (*riche en faits, en connaissances vraiment chimiques*), but unfortunately "it lost its way by rising up" (i.e. in speculations) (*[elle] s'est égarée en s'élevant*), while prevailing itself to be the art which makes possible to go up to 'divine Architect', or even "the rival & reforming art of

Nature (*[l'art] rival & réformateur de la Nature*); generally in Physics, one has often mistaken "abstract notions for truths of existence" (*notions abstraites avec vérités d'existence*).[40] However a paradox must be noted: French Physicists practised a Newtonian Physics which tended to 'disanimate' Nature while replacing it by an inert matter which cannot escape a strict mechanism because it was subjected to blind laws. Therefore one can think that 18th century Chemistry, by claiming the right to work in 'vagueness' and 'approximation', unlike Physics which, for Venel, wanted at all costs to explain everything, or which, according to Fontenelle, finds the first origins of everything "by delicate speculations",[41] let more place in its doctrine to Nature; Chemistry never really left Nature, in fact, it multiplied it.

Nevertheless the change in 18th century Chemistry was neither sudden nor necessarily radical. It was not sudden, because the recognition of only one instance of reality –the existence of bodies– was the completion of 17th century Chemistry movement (which has first rehabilitated the 'corporal' with the use of Salt Principle (Joseph Du Chesne), then the body with the practice of the second and palpable Principles (in Chemistry handbooks), and at last it had attempted to establish only probable –*i.e.* not 'metaphysical', not indemonstrable– Principles (Samuel Cottereau Du Clos, François Saint André[42]). It was not either necessarily radical, because the practice of Chemistry –which was not reduced to a simple empiricism– to try to determine a coherent order in the substance diversity for which Chemists can still use sometimes an indemonstrable Reason. But one can finally question oneself if the abandonment of a transcending Principle of unit in Chemistry in 18th century was not definitive.

Notes

[1] For some recent texts on the more materialist approach of phenomena in 18th century Chemistry, see: John C. Powers, "Chemistry Without Principles: Herman Boerhaave on Instruments and Elements", in Lawrence M. Principe (ed), *New Narratives in Eighteenth-Century Chemistry. Contributions from the First Francis Bacon Workshop, 21-23 April 2005* (Dordrecht: Springer, 2007), 45-61; John C. Powers, "Scrutinizing the Alchemists. Herman Boerhaave and the Testing of Chemistry", *in* Lawrence M. Principe (ed), *Chymists and Chymistry. Studies in the History of Alchemy and Early Modern Chemistry* (Sagamore Beach: Watson Publishing International LLC), 227-238; Ku-Ming (Kevin) Chang, "From Vitalistic Cosmos to Materialistic World", *in* Principe, *Chymists and Chymistry*, 215-225; Ursula Klein, "Experimental history and Herman Boerhaave's chemistry of plants", *Studies in History and Philosophy of Biological and Biomedical Sciences* 34 (2003): 533-567; Ursula Klein, W. Lefevre, *Materials in Eighteenth-Century Science. A Historical Ontology* (Cambridge MA: MIT Press, 2007).

[2] Pierre-Joseph Macquer, *Dictionnaire de Chimie, contenant la théorie et la pratique de cette Science, son application à la Physique, à l'Histoire Naturelle, à la Médecine, & à l'économie animale*, (Paris: 1766), 2 vol.
[3] Denis Diderot, Jean Le Rond d'Alembert (ed.), *Encyclopédie, Dictionnaire raisonné des Sciences, des Arts et des Métiers*, (Paris: 1751-1771), 17 vol.
[4] See Wilhelm Homberg, "Essays de chimie", *Mémoires de l'Académie Royale des Sciences* (1702): 33-52; and Rémi Franckowiak, Luc Peterschmitt, "La chimie de Homberg: une vérité certaine dans une physique contestable", *Early Science and Medicine* 10/1 (2005): 65-90.
[5] See Gabriel-François Venel, « Chymie », *in* Diderot, d'Alembert, *Encyclopédie*, 1753, vol. 3; and Rémi Franckowiak, "La chimie dans l'*Encyclopédie*: une branche tour à tour dépréciée, réévaluée et autonome", *Recherches sur Diderot et sur l'*Encyclopédie 40-41 (2006): 59-70.
[6] Venel, "Chymie", in *Encyclopédie*, vol. 3, 416b.
[7] Venel, "Chymie", in *Encyclopédie*, vol. 3, 416a.
[8] Venel, "Chymie", in *Encyclopédie*, vol. 3, 409a.
[9] See Rémi Franckowiak, "La chimie du XVIIe siècle: une question de principes", Methodos 8 (2008), Chimie et mécanisme à l'âge classique, [On line]. On line from 11 April 2008. URL : http://methodos.revues.org/document1823.html.
[10] Venel, "Chymie", in *Encyclopédie*, vol. 3, 409a.
[11] See Franckowiak, Luc Peterschmitt, "La chimie de Homberg"; and Rémi Franckowiak, *Le développement des théories du Sel dans la chimie française de la fin du XVI^e^ siècle à celle du XVIII^e^*, PhD dissertation (2002), part 2, § 1, forthcoming.
[12] About this Spirit, see Hiro Hiraï, *Le concept de semence dans la théorie de la matière à la Renaisance de Marsile Ficin à Pierre Gassendi* (Turnhout: Brepols, 2005); Rémi Franckowiak, "Le Sel de Joseph Du Chesne: premier moteur de la Nature", in *Actes du Congrès d'Histoire des Sciences et des Techniques (SFHST, Poitiers, 2004)* (Cahiers d'Histoire et de Philosophie des Sciences: Paris, 2006), 79-92.
[13] Jean-Jacques Rousseau, *Institutions chimiques* (1746-1753) (Fayard: Paris, 1999), 261.
[14] In *Mémoires de l'Académie Royale des Sciences*: Wilhelm Homberg, "Observation sur la quantité exacte des sels volatils acides contenus dans les différens esprits acides", (1699): 44-51; "Essais pour examiner les sels des plantes" (1699): 69-74; "Observations sur la quantité d'acides absorbés par les alcalis terreux" (1700): 64-71; "Observations sur les sels volatiles des plantes" (1701): 219-223. See Franckowiak, *Le développement des théories du Sel*, part 2, § 1.
[15] Etienne-François Geoffroy, "Table des différents rapports observés en chimie entre différentes substances", *Mémoires de l'Académie Royale des Sciences* (1718): 202-212.
[16] It is what Gaston Bachelard (*Le pluralisme cohérent de la chimie moderne* (Vrin: Paris, (1932) 2000), 22-23) said about the 19th and 20th centuries chemistry.
[17] According to Frederic L. Holmes (*Eighteenth-Century Chemistry as an investigate enterprise* (Berkeley: Univ. of California, 1989), 39-41), the affinity table was "a nodal point in the continuing evolution of a pragmatic chemistry of operations oriented around the concept of middle salts".
[18] Etienne-François Geoffroy, "Eclaircissements sur la Table insérée dans les Mémoires de 1718 concernant les Rapports observés entre différentes Substances", *Mémoires de l'Académie Royale des Sciences* (1720): 20-34.
[19] See Bernard Le Bovier de Fontenelle's review on Geoffroy's memoir, "Sur les rapports de differentes substances en Chimie", *Histoire de l'Académie Royale des Sciences pour l'année 1718* (1720): 35-37.
[20] Fontenelle, "Sur les rapports", in *Histoire de l'Académie Royale des Sciences*, 36.

[21] See, in *Mémoires de l'Académie Royale des Sciences*, for Stahlian reasons: Gilles Boulduc, "Mémoire sur la qualité & les propriétés d'un Sel découvert en Espagne, qu'une Source produit naturellement ; & sur la conformité & identité qu'il a avec un Sel artificiel que Glauber, qui en est l'auteur, appelle Sel admirable" (1724): 118-137; "Essai d'analyse en général des nouvelles eaux minérales de Passy ; avec des raisons succinctes, tant de quelques phénomènes, qu'on y aperçoit dans de différentes circonstances, que des effets de quelques opérations, auxquelles on a eu recours pour discerner les matières, qu'elles contiennent dans leur état naturel" (1726): 306-327; "Examen d'un sel tiré de la terre en Dauphiné ; Par lequel on prouve, que c'est un Sel de Glauber naturel" (1727): 375-383; and for mechanistic reasons after 1718: Louis Lemery, "Observation nouvelle et singuliere sur la Dissolution successive de plusieurs Sels dans l'Eau commune" (1724): 332-347; "Second mémoire, ou réflexions nouvelles sur une précipitation singuliere de plusieurs sels par un autre sel, Déjà rapportée en 1724, & imprimée dans le Tome de la même année, sous le Titre d'*Observation nouvelle et curieuse*, sur la dissolution successive de différents Sels dans l'eau commune" (1727): 40-49; "Sur le Sublimé corrosif ; Et à cette occasion, Sur un article de l'Histoire de l'Académie Royale des Sciences de l'année 1699, où il s'agit de ce Sublimé" (1734): 259-294; "Nouvel éclaircissement sur l'alun, sur le vitriols, et particuliérement sur la Composition naturelle, & jusqu'à présent ignorée, du vitriol blanc ordinaire" (1735): 262-280; "Supplément aux deux mémoires que j'ai donnés en 1735, sur l'Alun et sur les Vitriols" (1736): 263-301.

[22] See for instance, in *Mémoires de l'Académie Royale des Sciences*: Henri-Louis Duhamel du Monceau, "Sur le Sel Ammoniac" (1735): 106-116; "Sur la base du sel marin" (1736): 215-232; and Duhamel, Grosse, "Des différentes maniéres de rendre le Tartre soluble" (1732): 323-342; "Sur les différentes maniéres de rendre le Tartre soluble. Seconde Partie" (1733): 260-272. Nevertheless, if Duhamel had had to give some reasons for the affinities, they would have been Stahlian ones; see Duhamel, "Suite des recherches sur le Sel Ammoniac. Troisiéme Partie", *Mémoires de l'Académie Royale des Sciences* (1735): 500-501 and 504. For this development, see Franckowiak, *Le développement des theories du Sel*, part 2, § 2.

[23] Fontenelle, "Sur les rapports", in *Histoire de l'Académie Royale des Sciences*, 37.

[24] Nevertheless, it is true that Geoffroy writes twice in the first page of his memoir (p. 202) the word 'laws', but in the plural form. Indeed, for him, there are only particular laws for particular substances. Each law -i.e. each '*rapport*'- is about the specific regular behaviour of a single substance (except for the two chemical genera: acid spirits and metal substances). No natural law exists, but a 'steady rule' (*une règle constante*) (p. 212). According to Geoffroy, his Table represents just a 'method' (p. 203), not more.

[25] See Clément Rosset, *L'anti-nature* (Paris : PUF, (1973) 2004), about Empédocle, part III, §2.

[26] Combinations were not "a result of affinities", as Mi Gyung Kim says (*Affinity, That Elusive Dream: A Genealogy of the Chemical Revolution* (Boston: MIT, 2003), 145). The rapport table is not, as she also affirms it (pp. 144-146), "a theoretical system", and affinities do not represent "a theory domain" either, but just a "method" as Geoffroy simply presents it (p. 203). According to him, his table, built from chemical operations, has a practical "utility" (p. 206) indeed, since it is to lighten the practice. Geoffroy writes the "rapport" in Chemistry is a "property" (p. 203) of which the effects are thus observable in laboratory. Once its existence is noted, the "rapport" appears like the "key" -to take again Geoffroy's word (p. 203)- which allows explaining the recombining of substances mixed together, and only "predicts" (p. 206) what was already observed before or in other circumstances.

[27] See Rémi Franckowiak, "Rouelle, un vrai-faux anti-newtonien", *Archives internationales d'histoire des sciences* 150-151/vol. 53 (2003): 240-255. About Buffon, see Thierry Hoquet, *Buffon : Histoire naturelle et Philosophie* (Paris: Honoré Champion, 2005).
[28] Georges-Louis Leclerc comte de Buffon, *Histoire naturelle, générale et particulière, Servant de suite à la Théorie de la Terre, & d'introduction à l'histoire des Minéraux*, Supplément (Paris, 1774): vol. 1, 75.
[29] Guillaume-François Rouelle, "Mémoire sur les sels neutres, dans lequel on propose une division méthodique de ces sels, qui facilite les moyens pour parvenir à la théorie de leur crystallisation", *Mémoires de l'Académie Royale des Sciences* (1744): 353-365. See Rémi Franckowiak, "Les sels neutres de Guillaume-François Rouelle", *Revue d'Histoire des Sciences* 55/4 (2002): 493-532.
[30] "J'appelle sel neutre moyen ou salé, tout sel formé par l'union de quelqu'acide que ce soit, ou minéral ou végétal, avec un alkali fixe, un alkali volatil, une terre absorbante, une substance métallique, ou une huile" (Rouelle, "Mémoire sur les sels neutres", 353). Everybody will not accept the oil in the definition of neutral salts, like d'Holbach; see Paul Tiry d'Holbach, "Sel", *in* Diderot, d'Alembert, *Encyclopédie,* vol. 14, 903-904.
[31] See Guillaume-François Rouelle, "Sur le sel marin", *Mémoires de l'Académie Royale des Sciences* (1745): 57-79.
[32] See at the bottom of the final table in 1744 Rouelle's memoir, "Mémoire sur les sels neuters".
[33] See Franckowiak, *Le développement des theories du Sel*, part II, § 4.
[34] Georges-Louis Leclerc comte de Buffon, *Histoire naturelle des Minéraux* (Paris, 1783), vol. 2, 162.
[35] Antoine-Laurent Lavoisier, *Traité élémentaire de Chimie, présenté dans un ordre nouveau et d'après les découvertes modernes* (Paris, 1789), 128.
[36] Bachelard, *Le pluralisme* coherent, 68.
[37] See Bachelard, *Le pluralisme coherent*, 68-69.
[38] Paul-Jacques Malouin, "Alchimie", *in* Diderot, d'Alembert, *Encyclopédie,* 1751, vol. 1, 249a. See Franckowiak, "La chimie dans l'*Encyclopédie*", 59-60.
[39] See Venel, "Chymie"; Franckowiak, "La chimie dans l'*Encyclopédie*", and "Sur un air de chimie dans l'*Encyclopédie* », in *Revue sur Diderot et l'*Encyclopédie, forthcoming.
[40] See Venel, "Chymie", 408b-409a.
[41] Bernard Le Bouvier de Fontenelle, *Histoire de l'Académie Royale des Sciences, depuis son établissement en 1666 jusqu'en 1686*, (Paris, 1733), vol. 1, 79-81.
[42] Franckowiak, "La chimie du XVIIe siècle".