CHAPTER 4

THE NOTION OF A MIXT IN THE EIGHTEENTH CENTURY UP TO THE CHEMICAL REVOLUTION: THE EMPIRICIST SCHOOL

Alongside [37] these schools, a fourth arose after the seventeenth century, the empiricist school.

Fontenelle has left an intriguing catalogue of differences which frequently arose between chemists of the empirical school and those he calls chemist-physicists.

"Monsieur du Clos," he says[1], "continued this year with the examination that he had begun of the *Essays on chemistry* of Mr. Boyle ... Mr. du Clos, as great a chemist as Boyle, but perhaps with a more chemical turn of mind, did not find it necessary, nor even possible, to reduce this science to principles as clear as shape and movement, and he had no difficulty in accommodating a certain specious obscurity which had become well established. For example, if some Brazil wood is boiled in some alkaline sulphurated salt, an intense crimson colour is produced, which is lost and suddenly degenerates into a yellowish one by mixing with aqua fortis, spirit of saltpetre or several other mineral liquors. Mr. du Clos attributes this beautiful red to the excitement of the sulphurated salts, and Mr. Boyle to the new texture of the particles which form the surface of the liquid. Chemistry resolves substances into certain crude and tangible principles, [38] salts, sulphurs, etc. by visible operations. ... But physics, by delicate speculations, acts on the principles as chemistry does on substances; it resolves them into other principles yet more simple, into small bodies infinitely varied in shape and movement: that is the principal difference between physics and chemistry ... The essence of Chemistry is more confused, broader; it resembles more the mixts where the principles are more confused with one another. The essence of Physics is more distinct, simpler, clearer, seeking to return to first beginnings. The other does not go to the bottom."

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1 Fontenelle, *Histoire de l'Académie royale des Sciences*, t. I. Depuis son établissement en 1666 jusqu'à 1686. Année 1669. Physique, Chimie. Paris, 1733.

The portrait of the chemist that Fontenelle has outlined for us would certainly meet with the approval of Jean-Joachim Beccher, of Speyer. What cannot be found in his strange book on *Subterranean physics*[2]? Theological arguments by which he proves that the devil has reached the centre of the earth in his fall; stories of boundless incredulity, such as the anecdote about a maidservant who swallowed some frogs eggs and threw up six live frogs; the meaningless comparisons which made him think of metals as male minerals and stones as female minerals; important chemical observations and above all, violent diatribes against those who philosophise on chemistry.

Nevertheless, submitting either to current fashion or the influence of Boyle, whose small springs[3] he criticised, but whom he admired and befriended, Beccher dealt carefully with the atomists and the Cartesians. Sometimes, however, he seems to share the opinion of the Cartesians. At the beginning of his work[4], commenting [39] on the text *Deus creavit cœlum et terram*, he maintains that all material is composed of *sky* and *earth*. It is the *sky*, and not the air, that is the principle of rarefaction and condensation. The air does not possess the elastic force that is attributed to it because the air itself cannot be rarefied or condensed without the elasticity of the sky. Evidently, Beccher's *sky* has close affinities with the *subtle matter* of Descartes. Just as in 1699, the chemist from Speyer composed all things of *sky* and *earth*, the Cartesian Lémery had in 1675 composed all things of *subtle matter* and *earth*.

Beccher treated the Atomists and Cartesians leniently, reserving all his venom for the Peripatetics. Let us examine, he says[5], the doctrine of Aristotle's pupils regarding the mistion[6] of minerals. What does it teach? What everyone already knows. What does it provide us with? With names and covers to put on realities, after having emptied them. It tells us that minerals are *mixts* that are formed from *elements*, that they have *constitutions* and *qualities*. Who doesn't know that? But how are these mistions made and how are all the different kinds of minerals produced? That is the difficult question, where the efforts of our artful people stumble. Why is tin able to form a non-fragile alloy with lead, but not with silver?

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2 Joh. Joachimi Beccheri, Spirensis germani, Sacr. Coes. majest. consil. et med. Elect. Bav., *Physica subterranea* profundam subterranearum genesin ex principiis hucusque ignotis ostendens, 1699, 2nd. edition, 1738.

3 "Roberto Boyle præ omnibus nostro sæculo palmam concederem, si misso suo *elaterio*, chymica experimenta ulterius continuasset: et in exponendis istis non tam materiam *concludendi*, quam in singulis dubitandi, tractare sibi propsuisset." (Beccher, *loc. cit.*, Sectionis quartæ caput primum.)

4 Beccher, *Physica subterranea* liber primus. Sectio prima: de Creatione universi Orbis. Caput primum: De Creatione Coeli.

5 Beccher, *Physica subterranea* liber primus. Sectionis quartæ caput primum: De necessitate Physicæ circa Mixtionem.

6 [Since Duhem's *mixte* and *mélange* have been preserved in the English as 'mixt' and 'mixture', respectively, his *mixtion*, which appears for the first time here will be tracked in the English by 'mistion', even though this is, unlike the French, an antiquated term.]

It would be easy to give you a reason: they are contrary substances with different constitutions. But if you ask them in what the constitution of substances consists and in what respect they differ, then they are speechless. Aqua fortis dissolves metals; that is because, these philosophisers say, it possesses the *dissolving quality*. Certainly; and furthermore: *quantum est quod aliquid quantum dicitur*,[7] equally begging the question. But why does aqua fortis dissolve all metals with the single exception of gold? Here all philosophy is in confusion! How more noble is Spagyric[8]! It takes [40] as theses truths established in practice—experiences. To the phenomena of mistion and the characteristics of mixts it assigns true causes and solid grounds. It continuously reveals new combinations. Yet for all the sagacity, subtlety and meticulousness of this science, you will find not a word on it in the books of the philosophers. They feed only on ideas, abstractions and vain fancies; they only cling to names, happily ignoring their ignorance.

Elsewhere, we see Beccher hurl this whim at the Peripatetics[9]: "They say to you that qualities change, which everyone knows. But why have they changed, and how? Here, deep silence reigns. They would not succeed in explaining for you even if they sweated with their Aristotle for the whole of eternity."

Beccher's principal glory is his having had as a disciple the chemist who created the phlogiston theory, the medical doctor who conceived animism, the illustrious Georges-Ernest Stahl.

Like his master, Stahl[10] rejected the peripatetic theory of mixts. But it is fair to add that, in contradistinction to his master, his rejection was based on reasons and not on jokes. The peripatetic theory was connected, it seemed to him, with the contention that matter is infinitely divisible—a contention which he could not accept[11].

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7 [It is the size it is because it is the size it is said to be]

8 This name was used for a long time as a synonym for *Chemistry*.

9 Beccher, *Physica subterranea* liber primus. Sectionis quartæ caput tertium: Generalia quædam Axiomata de Mixtione continet.

10 Georgi Enesti Stahlii, Consil. Aulici et Archiatri Regii, *Fundamenta Chymiæ* dogmaticæ et experimentalis, et quidem tum communioris physicæ mechanicæ, pharmaceuticæ ac medicæ tum sublimioris sic dictæ hermeticæ atque alchymicæ; olim in privatos auditorum usus posita, jam vero indultu auctoris publicæ luci exposita. Norimbergæ, 1723.

11 Stahl, *Fundamenta Chymiæ*, pars III: "... Intellixit quidem, quod ipsi concedendum, quod si quantitas hujusce modi aggregati quovismodo imminuatur, ut sensibilis tantum pars remaneat, ibi illa pars adhuc tota sit mixta, et hæc pars per guttulas imo singulæ guttulæ in minores ulterius proportiones divisæ, tamen sint mixtæ, denn mag etwas zertheilen, so klein man will, so bleit doch das mixtum noch da; interim exemplum ipsum explicandæ mixtionis indoli nimis crassum est atque ineptum: Und ist daher darauf gefallen, das man ein Ding in infinitum secundum lineas mathematicas zertheilen könne."

A large part of Stahl's works are written in this bizarre mixture of German and barbaric Latin. One understands that Buffon was able to write "M. Macquer and M. de Morveau the first of our chemists to have spoken French. This science was therefore born when one began to speak

While [41] maintaining the excellence of the experimental philosophy, Stahl treated Cartesian and Atomist physics with respect: "Although the mechanical philosophy," he says[12], "is well adapted to explain all things, it is in the study of physico-chemical questions that it has been most daringly applied. I do not scorn moderate usage of this method; however, in order not to be blinded by preconceived views, it should be remembered that it [the mechanical philosophy] does not throw away a day on such questions. We should not be surprised. Most of the time it views these assertions with suspicion. It licks the surface and the skin of things, leaving the kernel intact. Concerning the shape and movement of particles it rests content to extract a very general and fairly abstract explanation of the phenomena. But it does not worry about knowing what mixts, compounds, and aggregates are, nor what their nature is, nor what are the properties of these sorts of bodies, nor in what they differ from one another."

In fact, Stahl had certainly meditated on the physico-mechanistic theories of Descartes, Boyle and Lémery, and he adhered to the essential principles of these theories.

At the beginning the second part of his work[13], he divides all bodies into fluids and solids, and ascribes to them a constitution which he borrows practically word for word from Lucretius. He corrects this doctrine only by the introduction of the Cartesian *subtle matter*.

Fluid bodies are not continuous, but contiguous: they are formed from separated, solid particles which are capable of movement. These [42] particles are small globes with smooth surfaces. They are all endowed with the same motive force by which they tend to fall with the same heaviness if the fluid is homogeneous; that is why the surface of liquids is always parallel to the horizon.

Fluid bodies condense when the pores which separate their particles become narrower, and dilate when the pores become larger. In the first case, a subtle matter which fills the pores is driven out, and in the second case the subtle matter penetrates the dilated pores.

The hardness of solid bodies is not due to the juxtaposition and lack of movement of the particles. Rather, solid bodies are formed from branched particles which are intertwined with one another in such a way that it would be very difficult to separate them. When one of the particles is displaced, it caries along with it all the others.

The chemist who accepts these principles could not fail to admit the theory which is common to the Epicureans and the Cartesians regarding the constitution of mixts, and so did Stahl.

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it." (Buffon, *Histoire naturelle, générale et particulière*, servant de suite à la théorie de la Terre et d'introduction à l'histoire des minéraux.—Supplément, tome I^{er} Paris, 1774.)

12 Stahl, *Fundamenta Chymiæ*, pars I. Préambule daté de 1720.

13 Stahl, *Fundamenta Chymiæ*, pars I, tractatus I, Proemium.

"Dissolution," he says[14], "is merely the division of bodies into very thin and smooth parts which force themselves into the pores of the menstruation, by way of forming a single fluid. But this division of the parts which constitute the whole could not be brought about if the liquid which is supposed to dissolve or to divide does not penetrate the pores of the bodies to be dissolved. It evidently follows that all dissolving must be the formation of parts which, by their shape and dimensions, fit into the pores of the dissolving bodies. A given liquid is therefore not able to dissolve all bodies, but only a certain ones."

"Besides, any body whatsoever is assembled and woven from particles which are not all alike, but on the contrary very dissimilar. These particles have very different shapes and [43] dimensions, and the variation of the texture, the position and the disposition of these particles confer on a given body diverse pores. One easily concludes that there should exist various menstrua whose smallest parts can penetrate the pores of these bodies."

"This granted, it is easy to understand why aqua fortis dissolves metals, but not wax or sulphur ..."

Doesn't it seem as though this page were taken from Lémery's *Cours de chymie*?

Particles of diverse *principles*, united in very intimate fashion, constitute a first class of bodies to which Stahl appropriately reserves the name of *mixts*[15]. Thus, *iron* is formed from salt, sulphur and mercury, but in certain proportions, and *acid salt of sulphur* is formed from salt and water. The union of principles in mixts is so intimate and so strong[16] that it is extremely difficult, if not impossible, to separate them. The mixt totally disappears without the decomposition of one chemical compound into another. Gold, for example, will be completely dissolved in the state of a tincture, will be totally amalgamated with mercury, will pass over entirely to the state of saline composition, and will become totally volatilised. Quicksilver treated with other saline materials will become "with all its weight" a salt. It will be possible to entirely revive it, and by whatever reagents it is precipitated, fixed, and extracted, it would be very easy to make it release the material with which it was united, and restore it to its first form of quicksilver, by means of contrary acids and alkalis, and even by means of very intense fire.

When the corpuscles of two or more [44] mixts are united together, they form a *compound* body[17]. The corpuscles of mixts which constitute a compound do not adhere to one another as strongly as the molecules of elements within a mixt.

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14 Stahl, *Fundamenta Chymiæ*, pars II; sectio I; caput II: De solutione et menstruis.

15 Stahl, *Fundamenta Chymiæ*, pars II.—Tractatus II: Doctrinæ chymicæ. Pars I, sectio III: De objecto chymiæ, Membrum I: De corruptione chymica.

16 Stahl, *Fundamenta Chymiæ*, pars II.—Tractatus I; sectio III: De combinatorium mixtorum.

17 Stahl, *Fundamenta Chymiæ*, pars II.—Tractatus II: Doctrinæ chymicæ. Pars I, sectio III: De objecto chymiæ, Membrum I: De corruptione chymica.

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