

CHAPTER 1

MIXTS ACCORDING TO THE ATOMISTS AND ACCORDING TO THE PERIPATETICS

Throw [11] a little sugar into a glass of water. After a short time, the solid, white crystalline body which constitutes the sugar has disappeared. The glass contains no more than a homogeneous liquid, transparent like water, but with a different taste. What is this liquid? The vulgar call it sugared water. The chemist says that it is a solution of sugar in water. These two descriptions correspond to two essentially distinct opinions.

Let us forget for the moment all chemical theory and analyse this simple operation of the preparation of a glass of sugared water.

Is there still any sugar or any water in the glass? No: the sugar has been eradicated; we have seen it gradually disappear. The liquid enclosed in the glass is no longer water—that is to say, that highly mobile, all but tasteless liquid, which provides the rain which fuels the springs which makes up the rivers—but a new liquid, more or less syrupy, whose sweet taste is reminiscent of that of the sugar which has served to form it. The glass therefore no longer contains either the water or the sugar which we had mixed there, but a new body, a *mixt*¹ formed at the expense of the two *elements*.

Nevertheless, even though the mixed substance, the sugared water, is no longer either water or sugar, it can be destroyed and the water and sugar from which it was formed regenerated. Warm it gently. It will evaporate [12] and we can, if we wish, condense the vapour and collect a water similar in every respect to that we had poured into our glass. During the evaporation, the sugared water disappears, depositing a white solid that we recognise as sugar. If the sugared water no longer *actually* contains the water and sugar from which it was formed, it can, by ceasing to exist, reproduce the water and sugar; it contains them *potentially*.

What in general, then, is a mixt? Some bodies, the one different from the other, are brought into contact. Gradually, they disappear, they cease to exist, and in their place a new body is formed, distinguished by its properties from each of *the*

1. [Duhem's substantive *mixte* is consistently translated with the old chemical term "mixt."]

elements which produced it by their disappearance. In this mixt, the elements no longer have any actual existence. They exist there only potentially, because on destruction the mixt can regenerate them. And the characteristics which determine the mixt belong not only to the body as a whole, but also to each part, however small, that the mind can cut out of the homogeneous body. Moreover, these characteristics are to be found in all mixts, both in what we today call mixtures² and that for which we reserve the name *chemical combination*.

This is, it seems, the clear, certain and obvious lesson that one is able to draw from the experience of the majority of people.

Not at all writes the chemist who, furthermore, loudly proclaims his empiricism and professes only to teach the facts! Such a notion of mixt, far from offering any certainty, is but a vulgar illusion, a gross deceit of our dull senses. It is unworthy of a mind capable of any reflection and contrary to the principles of sound physics.

Our eyes are too feeble to see an object one twentieth of a millimetre long, yet isn't it the witness of the eyes that you rely upon in order to affirm that water is a homogeneous and continuous fluid? [13] Take one of the microscopes that physicists have devised and perfected. Already in this liquid which you thought everywhere identical with itself, you see a multitude of unsuspected objects swimming before your eyes, and still the microscope has only made your sight one or two thousand times more powerful. How would it be if you were given, like the fabled Lynceus, limitless power of visual penetration? This water, which seems to you to fill in continuous fashion the volume of the containing glass, you would see as a collection of small solid bodies, separated from one another, which roll over one another without change of size or figure when the water is deformed and flows.

Each drop of water is thus composed of a multitude of *molecules*. The same holds for each small crystal of sugar. When sugar is put into the presence water, the molecules of sugar are not destroyed nor altered, but like prisoners who break away from their common chain, they are dissolved and, without breaking or modifying the molecules of water, they slip between them. The sugared water is therefore not at all homogeneous, with the smallest part possessing the same properties as the whole. The apparent homogeneity is only an illusion of our senses, which are very indelicate when it comes to perceiving the intimate structure of bodies. In sugared water, the water and the sugar subsist, juxtaposed, but not confounded. Sugared water might be called a mixture of sugar and water for the same reason that the contents of this sack is said to be a mixture of wheat and straw. In forming it, the sugar and water have no more ceased to exist in order to form a new body than the grain and straw have ceased to exist when the beater has thrown them higgledy-piggledy into the sack. Distillation which separates the water from the sugar no more regenerates the elements at the expense of the mixed body than the fan

2. [Duhem's substantive *mélange* is consistently translated as "mixture."]

recreates the wheat and the straw. It simply sorts molecules of different natures which the dissolution has jumbled together.

These two ways of conceiving the relation [14] of a mixture to the mixed bodies are both ancient. The Greek atomists regarded the homogeneity of a mixt as a mere appearance. The deficiencies of our senses alone prevent us from recognising the juxtaposition of the mixed elements. In the immortal lines in which the thoughts of the philosophers have been transmitted to us, Lucretius gave expression to his doctrine of mixts.³ Having described the branching and entangled molecules which comprise the tissue of solid bodies, the small, smooth globes free of all bonds which roll over one another in the midst of liquids, the pointed particles which constitute gases, he analyses the intimate structure of sea water. Among the smooth round bodies which give rise to its fluidity and which, when isolated, compose fresh water, other bodies are dispersed, also rounded, permitting them to follow the movements of the liquid, but rough and capable, because of their unevenness, of wounding the tongue and producing the experience of a bitter taste. These rough elements adhere to the soil, while smooth particles of water easily pass through the pores. Thus, sea water changes to fresh water by filtration on passing through the ground:

Sed quo amara vides eadem, quæ fluvida constant:
 Sudor uti maris est; minime id mirabile habendum,
 Nam quod fluvidum est, e lævibus atque rotundis
 Est: at lævibus atque rotundis mista doloris
 Corpora; nec tamen hæc retineri hamata necesse'st:
 Scilicet esse globosa, tamen cum squalida constant;
 Provolvi simul ut possint et lædere sensus.
 Et quo mista putes magis aspera lævibus esse
 Principiis, und'est Neptuni corpus acerbum;
 Est ratio secernundi, seorsumque videndi.
 Humor dulcit, ubi per terras crebrius idem
 Percolatur, ut in foveam fluat, ac mansuescat.
 Linquit enim supra tetri primordia viri
 Aspera, quo magis in terris hærescere possunt.⁴

3. Lucretius, *De rerum natura*, lib. II, vers. 390-476

4. [lines 464-477, translated by Cyril Bailey as follows: "But because you see that some things which are fluid, are also bitter, as is the brine of the sea, it should be no wonder. ... For because it is fluid, it is of smooth and round particles, and many rugged painful bodies are mingled in it; and yet it must needs be that they are not hooked and held together: you must know that they are nevertheless spherical, though rugged, so that they can roll on together and hurt the senses. And that you may the more think that rough are mingled with smooth first-beginnings, from which is made the bitter body of the sea-god, there is a way of sundering them and seeing how, apart from the rest, the fresh water, when it trickles many a time through the earth, flows into a trench and loses its harshness; for it leaves behind up above the first-beginnings of its sickly saltness, since the

To this doctrine the peripatetics objected that a mixed body is really distinct from the bodies from which it is formed. In producing the [15] mixt, the elements cease to exist. The mixt only comprises them as a potentiality; when decomposed, it can regenerate them. The exposition that we have just given of the two contradictory opinions of the nature of a mixt is hardly more than a paraphrase of what Aristotle says.⁵

rough particles can more readily stick in the earth." *Titi Lucreti Cari De rerum natura libri sex*, edited with prolegomena, critical apparatus, translation, and commentary by Cyril Bailey, © 1947 Clarendon Press, Oxford; p. 261. Reproduced by permission of Oxford University Press.]

5. Aristotle, *Περὶ γενέσεως καὶ φθορᾶς* [*De generatione et corruptione*], Bk. I, chap. x.



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