

Oldroyd, D. R.

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D. R. Oldroyd (Australia)

THE DOCTRINE OF PROPERTY — CONFERRING PRINCIPLES IN CHEMISTRY: ORIGINS AND ANTECEDENTS

It is not easy to give a general characterization of the state of chemical theory in the period immediately before the so-called "chemical revolution" of the eighteenth century, but historians do now seem to be in fairly wide agreement that an important and characteristic feature of the Stahlian chemistry — if so we may call the general theoretical framework of the pre-revolutionary chemists — was that it was a chemistry of *principles*, each "principle" having its own property-conferring responsibility. There was, of course, little agreement as to the nature and number of these *principles*, and generally they managed to elude "chemists" attempts to isolate them and cork them up for inspection in separate bottles. But this was not necessarily considered an insuperable difficulty. As Richard Watson wrote, in a rather well-known passage, with respect to phlogiston, that most eminent of all chemical principles:

You do not surely expect that chemistry should be able to present you with a handful of phlogiston, separated from an inflammable body; you may just as reasonably demand a handful of magnetism, gravity, or electricity, to be extracted from a magnetic, weighty, or electric body. There are powers in nature which cannot otherwise become the objects of sense, than by the effects they produce; and of this kind is phlogiston¹.

So, for Watson, phlogiston was a typical scientific entity², one that could be invoked in order to explain puzzling phenomena, and which

¹ R. Watson, *Chemical Essays...*, 6th edn., 5 vols., London 1973, vol. 1, p. 167.

² I use this term in the same sense as that adopted by J. B. Thornton, in an undeservedly disregarded paper: Scientific Entities, "The Australian Journal of Philosophy", 31 (1953), pp. 1—21; *Ibid.*, pp. 73—100.

was not, in itself, in need of further explanation. It was of little consequence to him that phlogiston could not be isolated.

It is true, of course, that many late eighteenth-century chemists were unwilling to accept this protean entity in these terms, and laboured mightily to effect its capture and subject it to the discipline of the balance. It is true also that a number of the features of the Stahlian phlogiston rose again in the caloric of Lavoisier, so that one can discern many common features between the pre- and post-revolutionary doctrines. But these considerations need not detain us here, though they will be referred to again briefly below. Let us, rather, give some thought to the question of the origins and antecedents of the general doctrine of property-conferring principles, and the general ontological position that they represented.

The first stages of such an enquiry may be performed easily enough. Watson's phlogiston is evidently just one expression of the Stahlian theory, and, as I have described elsewhere³, Stahl's chemical system was based firmly on the doctrine of property-conferring *principles*. As is well known, Stahl's phlogiston was drawn from the *terra pinguis* of Becher, which, together with the *terra vitrescibilis* and the *terra mercurialis* formed his triad of earthy principles, and components of the universe.

What, we may ask, were the special ontological characteristics of Becher's three "earths"? Taking his "vitrescible principle" as our example for discussion, it may be noted that he suggested⁴ that quartz was a close approximation to the "ideal principle" of vitrifiability, though it was not itself truly that "principle". Quartz, thought Becher, possessed the properties of fusibility and solidity to an exceptional degree, though it was not the perfect manifestation of such qualities. It would seem that he held in his mind's eye the notion of some "principle" that possessed vitrescible properties in an "ideal" manner — so much so that it imparted them to substances of which it was a constituent. So we might call the *terra vitrescibilis* the "essence" of glassiness, whence we may see Becher's theory as a manifestation of an "essentialist" mode of thinking in science, in that his three "earthy principles" (and water) served as ultimate explanations in accounts of chemical phenomena — in a manner that one such as Popper would thoroughly deplore⁵. Should an enquirer have asked Becher the reason for a parti-

³ D. R. Oldroyd, *An Examination of G. E. Stahl's Philosophical Principles of Universal Chemistry*, "Ambix", 20 (1973), pp. 36–52.

⁴ J. J. Becher, ... *Physica subterranea...*, Leipzig 1703, p. 123 and *passim*. (The first edition was published in Frankfurt in 1669).

⁵ See, for example, K. R. Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge*, 3rd edn., London 1969, p. 104.

cular substance having a glassy texture, he would, no doubt, have offered an explanation in terms of the vitrescible "principle". No further explanation would have been deemed necessary; and, so far as Becher might have been concerned, the enquirer would have had to have taken it, or to have left it, so to speak. Later investigators, however, did seek to isolate and weigh such hypothetical entities as Becher's first "earth".

If it is possible to construe the theory of Becher as being essentialist in character, according to the role his chemical principles played in a system of scientific explanation (as it appears from a twentieth-century stand point), it is also, I think, possible to view it in a similar light when its historical antecedents are examined. Thus, it can be argued, I suggest, that the chemical theory of Becher had certain quasi-Platonic features; and it is customary to consider the 'forms' of Plato or the Neo-Platonists as supposed expressions of the 'essences' of things. Again, as I have pointed out elsewhere⁶, Becher speaks of the "idea" of the *terra vitrescibilis* being expressed by a most subtle and penetrating spirit permeating the Earth — a notion that was quite commonplace in the seventeenth century for writers in the Paracelsian tradition, with its several Neo-Platonic characteristics. Becher's usage of this term, I suggest, indicates that his thinking was, in part at least, influenced by Neo-Platonic doctrines. And, to my mind, the very employment of the notion of chemical "principles" points to a quasi-Platonic or Neo-Platonic epistemology or ontology. For just as (for a Platonist) an "ideal" triangle of the world of "forms" might be suggested by an actual triangle drawn in the dust or on a philosopher's page, so, for Becher (I suggest) the "ideal" vitrescible "principle" might have been suggested by mundane specimens of quartz.

The situations are not, it is true, exactly parallel. For whereas the Platonic forms were envisaged as being transcendental, immaterial essences (or ideas in the mind of God, for the Neo-Platonists), the three "principles" of Becher were held to be actually present within lumpish specimens that might be held in the hand. And, despite their "ideal" character, the attempt to isolate these immanent "principles" did provide a research programme of considerable importance for many chemists of the eighteenth century, though, as we have seen, some, such as Richard Watson, renounced any hope of obtaining tangible specimens of such 'principles', and indeed denied that any research programme with this end in view was viable. By contrast, no Platonist would ever have expected to see or touch an "idea" or a "form".

⁶ D. R. Oldroyd, *Some Phlogistic Mineralogical Schemes, Illustrative of the Evolution of the Concept of 'Earth' in the 17th and 18th Centuries*, *Annals of Science*, 31 (1974), pp. 269—305.

So Becher's "principles", I say again, had certain quasi-Platonic features; yet they cannot be described in a wholly satisfactory manner by means of this simple label. They were not transcendental essences (or Platonic "forms"), but were envisaged rather as material components of mixts, the starting points for systems of chemical explanation, and possibly as subjects for empirical chemical analysis and synthesis. They were immanent essences, though not of an Aristotelian character (mere verbal definitions) which, as will be discussed below ⁷, provided another important antecedent of the seventeenth- and eighteenth-century doctrine of chemical "principles".

If, then, we can view Becher's "principles" as essences of a kind, or as having evident essentialist features, it will be convenient to coin a term to denote their particular character. Let us, therefore, refer to them as reified essences, using this term to signify the thought that they provided the starting points for systems of chemical explanation and had many of the features of metaphysical essences, yet they were thought of as material components of things. They were distinct from the logical essences of the Aristotelian scholastics.

Although one can, with some justice, trace much of the chemical theory of the first half of the eighteenth century, via Stahl, to Becher, it is quite obvious, and no historical discovery of mark, that the theory of the three "earths" was beholden to the doctrine of the "tria prima" of Paracelsus and the Paracelsians, and well before Becher there were men who described in some detail processes for the supposed extraction of property-conferring "principles". Beguin, for example, gave the following account of the extraction of the three so-called "hypostatick principles":

... by examples taken from the various kind of mixt things, we shall, for the benefit of young Beginners, delucidate everything. We will first begin with green Woods, which if you burn, there will come forth a certain Wateriness, which is plainly apt for taking flame; and if gathered when converted into fume, it is resolved easily into water (and by the same reasons, to seek drink from a flame is not impossible) and this is called Mercury: then there goes forth an oleaginous substance easily inflammable, which resolved into vapours, if taken, will pass into Oil, and that is called Sulphur: at length a dry and terrestrial substance remains, which from the ashes, by the benefit of water is extracted, and in the humid and cold it is dissolved, but in the heat congealed, and it obtains the name of Salt ⁸.

⁷ Page 9, ff.

⁸ J. Beguin, *Tyrocinium chymicum: or, Chymical Essays, Acquired from The Fountain of Nature, and Manual Experience*, London 1669, p. 22. (Partington records that this was translated from the Latin Paris edition of 1612, the first edition (s. 1.) having appeared in 1610). It should be noted that on page 21 of the edition cited Beguin refers to the chemical principles as being "Spiritual, by reason of the influx of celestial Seeds".

Here, in the famous experiment of the "green stick", we see the doctrine of the *tria prima* given a strongly empirical interpretation. It is generally agreed, however, that a recognition of this baldly empirical approach does not give anything like the complete picture, so far as the matter theory of Paracelsus himself was concerned, and account must be taken of its "spiritual" aspects. Thus Pagel emphasizes that matter, for Paracelsus represents a corporification of spirit, and should be thought of as a "pattern of spiritual forces" — a pattern that is at its simplest, and most easily discerned, in the *tria prima*⁹. In addition, Pagel draws particular attention to the "seminal" aspects of Paracelsus's doctrine¹⁰, stemming from the Stoic *logoi spermatikoi* of the ancient world.

It is evident from the foregoing that in some of its features at least Paracelsus's matter theory also, with its "spiritual" aspects, stands as a descendant of the long tradition of Neo-Platonism¹¹. Let us, therefore, look briefly at some aspects of this tradition.

In Plato himself, we have an ultimate duality between the transcendental world of "forms" and the mundane world of phenomenal experience, scarcely bridged by the constructive activities of the *demiurge* of the *Timaeus*. This gap is filled in the doctrines of the Neo-Platonists, but at the expense of making ultimately spiritual in character that which we think of as material substances. Plotinus wrote:

There exists a Principle which transcends Being; this is the One... Upon The One follows immediately the Principle which is at once Being and the Intellectual-Principle. Third comes the Principle, Soul¹².

And:

... there is from the first principle to ultimate an outgoing in which unflinchingly each principle retains its own seat while its offshoot takes another rank, a lower, though on the other hand every being is in identity with its prior as long as it holds that contact¹³.

Generally the Neo-Platonists used the model of irradiation from some source to convey the nature of the relationship between the "One" and the things given material existence by the "One"¹⁴. The analogy

⁹ W. Pagel, *Paracelsus: An Introduction to Philosophical Medicine in the Era of the Renaissance*, Basle and New York 1958, pp. 83—84.

¹⁰ *Ibid.* 85.

¹¹ The Hermetic tradition (which ultimately had Neo-Platonic roots also) should be considered in addition.

¹² Plotinus, *The Enneads*. Translated by Stephen MacKenna. Third edition revised by B. S. Page with a foreword by Professor E. R. Dodds and an introduction by Professor Paul Henry, S. J. London 1962, 378 (*Enneads* V. I. 10).

¹³ *Ibid.*, 381 (*Enneads* V. II. 2).

¹⁴ See, for example, Proclus, *The Elements of Theology*. A Revised Text with Translation, Introduction and Commentary by E. R. Dodds, Oxford, 1933, p. 71 and *passim*. Plotinus himself also made much use of this model. E. g., *op. cit.* (12), 394 (*Enneads* V. III. 12) and *passim*.

of the multiple reflection of light in many mirrors was used by Macrobius¹⁵, through whom, in particular, Neo-Platonic thought became widely disseminated in the Medieval period¹⁶. The pagan Neo-Platonism was given a Christian dress by "Dionysius the Areopagite", who also used the mirror model in his discussions of the so-called "celestial hierarchy"¹⁷. It was this hierarchy that was represented so graphically by Dante¹⁸, and became part of the regular mental furniture of the Medieval and Renaissance mind. And, as Pagel points out¹⁹, one can see much evidence for this venerable tradition in Paracelsus's doctrines.

Now in this Neo-Platonic tradition, there is an intended, though perhaps mysterious, causal link, by "emanation", between the "One" and the properties of individual things of everyday experience. Thus ultimately, for a Neo-Platonist, properties of a thing are accounted for in terms of a transcendental "essence", the gap between essence and object being bridged by a kind of emanatory process, mysterious to most moderns, but hopefully made somewhat intelligible to the enquirer by the employment of the analogy of the emanation of light from luminous objects. In Paracelsus, then, we have an interesting amalgam of this doctrine with other aspects of matter theory stemming from antiquity, some of which will be discussed below. There is a partial "reification" of the Neo-Platonic essences, in that Paracelsus employs archetypal notions of a Neo-Platonic character, but these archetypes are conceived as immanent, or within individual substances, with the corollary that the material objects are envisaged as being ultimately spiritual in character. There are, then, immanent essences, though they are not yet envisaged as being purely material²⁰. This stage was soon reached, however, by the disciples of Paracelsus, as has been shown by the quotation from Beguin given above²¹. In Becher, the reification of the model is largely complete, and the eighteenth-century Stahlians such as Rouelle or Macquer would have firmly repudiated any suggestion that their theories referred to anything spiritual — beyond things, properties

¹⁵ Macrobius, *Commentary on the Dream of Scipio*. Translated with an Introduction and Notes by William Harris Stahl, New York 1952, p. 145.

¹⁶ See: *The Cambridge Medieval History planned by J. B. Bury, ...* Edited by J. R. Tanner..., C. W. Previté-Orton..., Z. N. Brooke, 8 vols., Cambridge 1913—36, vol. 5, p. 790.

¹⁷ *The Celestial and Ecclesiastical Hierarchy of Dionysius the Areopagite now first translated into English from the original Greek, by the Rev. John Parker, M. A. ...*, London 1894, pp. 21—22.

¹⁸ For a fine modern version of Dante's poem in English, see: Dante Alighieri, *The Divine Comedy* translated by Thomas G. Bergin illustrated by Leonard Baskin, New York 1969.

¹⁹ W. Pagel, *op. cit.*, (9), p. 89.

²⁰ One might, despite the risk of being thought facetious, refer to them as "semi-reified essences".

²¹ See p. 6.

and compositions, and the relations between components and properties. Macquer, for example, simply described an essential oil as a volatile component that might be distilled from a plant²². He had no thought that it bore any relation to some metaphysical essence, either transcendental or immanent.

Here, then, in the Neo-Platonic tradition of celestial hierarchy, transcendental essences, or the crystallization of matter from a presumed "world-spirit", we have one important component of the theory of property-bearing chemical principles. Thus, it is my contention that the presumed causal link in Becher's theory between "essence" (or property-conferring "principle") and chemical property was essentially the same in kind as the link between transcendental essence and mundane attribute that was presumed in the traditional Neo-Platonic ontology. This despite the fact that for Paracelsus, a key figure in this tradition, the special qualities of things were not thought to be borne by particular material components²³.

Let us now examine a second important tradition, leading from antiquity and flowing forwards in time to form another important component of the doctrine of property-conferring principles. This second stream, the Aristotelian tradition, offers somewhat greater difficulties than the first. Let us begin the discussion by looking briefly at some of the notions of Aristotle himself.

In Aristotle, the Platonic doctrine of forms and essences is taken over, but the forms are construed as being immanent in things — in no way transcendental. However, the essence of a thing was not to be found by any process of chemical analysis (nor by any kind of mystical intuition), but by seeking a suitable definition in terms of genus and species, whence the properties or attributes of the thing might be obtained by ratiocination:

A definition is a phrase indicating the essence of something²⁴.

And:

A property is something which does not show the essence of a thing but belongs to it alone and is predicated convertibly of it²⁵.

The actual example given by Aristotle to illustrate this doctrine, namely that man is a "rational animal" (from which formal definition one might hope to infer that man is an entity capable of learning grammar), is not, we might think, satisfactory, for we do not perceive any logical connection between being rational and having the capacity

²² P. J. Macquer, *Dictionnaire de Chymie*... 2 vols., Paris 1766, vol. 1, p. 589 ff.

²³ W. Pagel, *op. cit.*, (9), p. 85.

²⁴ Aristotle, *Posterior Analytics* by Hugh Tredennick, ... *Topica* by E. S. Forster, ... Cambridge (Mass.) and London 1960, p. 281. (*Topics*, I. V.).

²⁵ *Ibid.*, p. 283.

to learn grammar. Nevertheless, if the programme had been restricted to this logical aspect, it would have been harmless enough, and would not have had any specially deleterious effects, so far as the subsequent history of the theory of matter was concerned. Unfortunately, however, right from the start, logic became conflated with ontology, and it was this double-edged character of Aristotle's essentialism that was to have a particularly confusing effect upon subsequent thought.

The multiple aspects of Aristotle's doctrine of 'essence' are most evident in the *Metaphysics*, where he himself listed a four-fold usage:

The term "substance" [ousia] is used, if not in more, at least in four principal cases; for both the essence and the universal and the genus are held to be the substance of the particular, and fourthly the substrate²⁶.

This is not the place to attempt to clarify in detail these multiple usages²⁷. In brief, however, it may be said that the universal and generic aspects refer to a logical kind of essentialism, such as may be found in the *Topics* or the *Categories*; the substrate refers to the underlying *hyle* of the *Physics*; and the "essence" refers to the characteristic Aristotelian doctrine of "form" or *eidōs*. If we concentrate on the non-logical aspects of the doctrine it is not difficult to find passages in the *Metaphysics* that emphasize the view of *ousia* as some kind of property-conferring material component of things:

Substance is a kind of principle and cause²⁸.

... substance is the indwelling form, of which and of the matter the so-called substance is composed²⁹.

... what we are seeking is the cause (i.e. the form) in virtue of which the matter is a definite thing; and this is the substance of the thing³⁰.

Since, however, Aristotle did not have any satisfactory method for arriving at a knowledge of the "indwelling form", "substances" or "essences", other than a linguistic treatment — a discussion of the way in which terms were used in everyday Greek, and a search for suitable definitions in terms of genus and species — it can be seen very readily that there would be a conflation and confusion of approaches at the logical and the ontological levels.

²⁶ Aristotle, *The Metaphysics Books I—IX* With an English Translation by Hugh Tredennick, ... London and Cambridge (Mass.), 1961, pp. 315—316.

²⁷ For a full discussion, see, for example: J. Owens, *The Doctrine of Being in the Aristotelian 'Metaphysics': A Study in the Greek Background of Mediaeval Thought*, 2nd edn., Toronto 1963, An account of Aristotle's *Metaphysics* that I have found particularly useful is: E. S. Haring, *Substantial form in Aristotle's Metaphysics Z*, "Review of Metaphysics", 10 (1956), pp. 308—332; 11 (1957) pp. 482—501 and 698—713.

²⁸ Aristotle, *op. cit.* (26), p. 395.

²⁹ *Ibid.* p. 371.

³⁰ *Ibid.*, p. 397.

Before leaving this very brief discussion of Aristotle's position, it should be noted that in his chief chemical treatise, *On Coming-to-be and Passing-away*, in which there is a detailed discussion of the constitution of matter and its changes, there is little utilization of any notion of immanent 'essences' with property-conferring responsibilities, though, as the title of the work makes obvious, Aristotle is here concerned primarily with the formation of things, rather than their existential properties. In the last analysis, he ascribes the generation and corruption of things to the motions of the heavenly spheres³¹, which was natural enough in view of the obvious seasonal growth and decay of plants and animals.

The logical works of Aristotle were transmitted to the modern western world via Porphyry and Boethius, and the Arabic commentators such as al Farabi, Avicenna and Averroës. The Arabs also wrote important commentaries on the *Metaphysics*, adding their own glosses thereto. This process of transmission led to a considerable admixture of Neo-Platonism, and a further confusion of logic and ontology³².

Al Farabi gave a clear and concise summary of Aristotle's doctrine of matter and form, without attempting any very significant modification of it³³. Avicenna, however, whose interest in Aristotle was stimulated by al Farabi³⁴, elaborated the doctrine considerably, describing a body as a composite of matter and form, though the form was not conceived merely as a shape, colour, smell, etc. Neither was it just a verbal definition, suitable as a starting point for the deduction of properties. Rather, Avicenna held that:

... the substratum of a material form is not an actuality without a material form. It is an actual substance due to the material form. In reality, therefore, the material form is the substance. It is not the case that substratum of matter is in itself an actual thing and that the material form is a necessary accident of it³⁵.

³¹ Aristotle, *On Sophistical Refutation, On Coming-to-be and Passing-away* by E. S. Forster ... *On the Cosmos* by D. J. Furley, London and Cambridge 1965, p. 315.

³² This overlapping of logic and ontology was not confined to the Aristotelian tradition, but also appeared among Neo-Platonists, E. R. Dodds, for example, has noted, with respect to Proclus, that the "fundamental weakness seems to me to lie in the assumption that the structure of the cosmos exactly reproduces the structure of Greek logic" and "the Aristotelian apparatus of genus, species and differentia is transformed into an objectively conceived hierarchy of entities or forces". E. R. Dodds, *op. cit.* (14), XXV.

³³ See: *Alfarabi's Philosophy of Plato and Aristotle*. Translated with an Introduction by Muhsin Mahdi, New York 1962, Part III: *The Philosophy of Aristotle*.

³⁴ See: A. M. Goichon, *Avicenna The Philosophe of Being*, [in:] V. Courtois (ed.), *Avicenna: Commemoration Volume*, Calcutta 1956, pp. 107—117, 108.

³⁵ P. Morewedge, *The Metaphysics of Avicenna (ibn Sina): A critical translation — commentary and analysis of the fundamental arguments in Avicenna's Metaphysica in the Danish Nama-i'ala'i* (The Book of Scientific Knowledge) London 1973, p. 24.

This gives an expression of the celebrated peripatetic doctrine of 'substantial forms'. Fortunately, the conflation of these with logical essences or forms was largely avoided in Avicenna.

By contrast, for Robert Grosseteste, writing within the tradition of European scholasticism, logical and ontological "forms" (or "essences") were regarded as one. He thought of "forms" as principles "through which particular things are what they are"³⁶. But they were also considered as the starting point for logical demonstrations.

With Aquinas, we get the classic scholastic exposition of the Aristotelian doctrine of "forms", but once again there is an awkward ambivalence in the discussion:

Now since everything acquires its generic or specific nature through its form, and since that generic or specific nature is the content of the definition declaring what a thing is, it follows that the form of a thing is a determinate predicate, its 'ratio' or logical definition, by which we know what a thing is. For although a definition may contain certain material elements, nevertheless its chief component must derive from the form of the thing defined. This, therefore, is the reason why forms are causes: that they give the completeness of the logical nature (ratio) of a thing's essence (quidditas)³⁷.

It will be noted that although the "essence" is regarded here as a logical "principle", from which, by ratiocination in the approved Aristotelian manner, one may derive the relevant properties of a thing, it is also seen as some kind of causative agent. Again, in the *Summa contra Gentiles*, Aquinas describes the 'form' of a thing as that whereby it is what it is:

Wherefore in things composed of matter and form, neither matter nor form, nor even being itself, can be described as that whereby it is, foreasmuch as it is the principle of being: but the whole substance is what is; and being is that whereby the substance is called a being³⁸.

Thus although, for a Thomist, the essence of a thing is strictly an intellectual entity — that whereby the nature of a things is apprehended — there is also a blurring with the notion of some causative agent, which, when united with matter, makes the matter into a thing of a particular kind. However, as we have seen, this dual aspect of the doctrine of form can be traced right back to the Aristotelian corpus itself, and did not originate in the work of Aquinas.

As a last example from the purely philosophical tradition, I select

³⁶ See: A. C. Crombie, *Robert Grosseteste and the origins of experimental science 1100—1700* Oxford 1953, p. 57.

³⁷ Thomas Aquinas: *Selected Writings* edited by the Rev. Father M. C. D'Arcy, London and New York 1939, pp. 156—157 (Metaph. 51, ii).

³⁸ *The Summa Contra Gentiles of Saint Thomas Aquinas...*, 4 vols., London 1923—1929, vol. 2, p. 127 (*Summa*, Book II, Chapter 54).

Duns Scotus, for whom "form", once again, had a markedly dual aspect. It was, as for Aquinas, a ground of intelligibility, but also:

Form is that which communicates to matter its state of being, its actuality, and its activity³⁹.

Here, apparently, "form" is held responsible for the particular properties of a thing being what they are.

Bearing in mind now this somewhat ambivalent philosophical tradition, let us turn to a consideration of examples of the earlier chemical writings that made use of the Aristotelian doctrines of "form" and "essence". Early writers in the "magical", Hermetical tradition, such as Agrippa⁴⁰ and Porta⁴¹, made use of the concept of "form", but related it to a Neo-Platonic metaphysic, ascribing the attributes of the "form" of a thing to some divine "idea" or act of volition. In the early years of the seventeenth century, however, when science was coming to exist as a discrete entity, distinct from philosophy or magic, but a little before the "scientific revolution" itself, it is quite common to find texts that display clear Aristotelian features, largely free from the Neo-Platonic doctrines that formed the basis of so many explanations in the fifteenth and sixteenth centuries. Thus, before the rise of the "mechanical philosophy", a considerable number of seventeenth-century writers chose to utilize the old peripatetic doctrines of "matter" and "form", stemming from the philosophical tradition that has been discussed above, in works that were really of scientific intent.

The Belgian naturalist Boethius de Boodt, for example, referred to the efficient, material and formal (but not the final) causes of minerals, and the "substantial forms" of stones and gems. He described the special virtues and faculties of these as flowing⁴² from their hidden essences and forms (a term commonly used to refer to the derivation of properties from "logical essences" or verbal definitions), whereas their more obvious powers allegedly stemmed from their material substance. Thus one can discern evidence for the continuation of the tradition of overlap of logical essences and ontological principles in the writings of this seventeenth-century natural historian. De Boodt also, however, spoke of

³⁹ C. R. S. Harris, *Duns Scotus*, 2 vols., Oxford 1927, vol. 2, p. 88.

⁴⁰ H. C. Agrippa (1486—1535), *Three Books of Occult Philosophy, written by Henry Cornelius Agrippa, of Nettesheim, Counsellor to Charles the Fifth, Emperor of Germany: and Judge of the Prerogative Court*. Translated out of the Latin into the English Tongue, by J. F., London 1651, pp. 24, 30 and *passim*.

⁴¹ J. P. Porta (1535—1615), *Natural Magick by John Baptista Porta, a Neapolitane: in twenty books: ... Wherein are set forth All the Riches and Delights of Natural Sciences*, London 1658, pp. 6—7.

⁴² A. Boethius de Boodt, ... *Gemmarum et lapidum historia, qua non solum ortus, natura, vis precium, sed etiam modus quo exiis, olea, salia, tincturae, essentiae, arcana magisteria arte chymica confici possint, ostenditur...*, Hanover 1609, p. 13.

“seminaries”, “architectonic spirits”, and the emanation of divine influences, as playing a part in the genesis of mineral substances. Clearly, therefore, there were definite Neo-Platonic ingredients as accompaniments to the Aristotelianism.

Such Neo-Platonic features are less prominent in the writings of Estienne de Clave, primarily an Aristotelian⁴³. He referred to the “form” of stones as something that could not be detected by the senses directly, but could only be apprehended by its effects⁴⁴ (cf. Watson’s remarks about phlogiston, given above). In a later publication, referring to what he took to be the five elementary “pinciples” (water, spirit, oil, salt and earth), de Clave wrote:

... le genre de ces cinq corps est element ou principe, distingué, par la propriété spécifique, comme disent Aristote, & Porphyre apres luy, par les proprieté qui dependent immediatement de la forme, ou si vous voulez de la nature de ce principe ou element⁴⁵.

Note that he states that properties depend on the “forms”. The property of congealability supposedly derives from the “form” of water; fermentability arises from the ‘form’ of mercury (or spirit); inflammability comes from the ‘form’ of sulphur (or oil); coagulability comes from the “form” of salt; and friability allegedly stems from the “form” of earth. It is true that there is a presumed causal dependence between “principle” and property, but, hovering in the background, there also seems to be an assumption of some kind of dependence arising from logical connections. I am inclined to suggest, in fact, that there was a certain degree of confusion between essences at the logical and ontological levels, so that the proposal of property-conferring “principles” as a feature of chemical explanation seemed quite natural to men accustomed, in the scholastic tradition, to tracing out logical links between formal definitions and properties.

If we are looking for a particularly clear exhibition of the peripatetic doctrine of “forms” having a leading influence on a seventeenth-century writer on matter theory, we cannot do better than consult the work of Daniel Sennert, a man whose publications are of special interest in this

⁴³ I refer to de Clave as an Aristotelian, for it seems to me that the overall framework of his science is determined by this tradition. It should be noted, however, that at one time he fell foul of the authorities for holding what were construed to be anti-Aristotelian opinions. See J. R. Partington, *A History of Chemistry*, 4 vols., London 1961—70, vol. 3, p. 8.

⁴⁴ E. de Clave, *Paradoxes, ou traittez philosophiques des pierres et pierreries, contre l'opinion vulgaire. Ausquels sont demonstrez la matiere, la cause efficiente externe, la semence, la génération, la définition, la nutrition d'icelles. Ensemble la génération de tous les mixtes, sçavoir est des animaux, vegetaux, mineraux, ou fossiles*, Paris 1635, pp. 411—412.

⁴⁵ E. de Clave, *Nouvelle lumière philosophique des vrais principes et éléments de la nature, qualité d'iceux. Contre l'opinion commune...*, Paris 1641, p. 160.

context since, as is well known⁴⁶, he was developing the old Medieval idea of "minima", so that it was beginning to bear some resemblance to the doctrine of atoms.

Sennert attempted to distinguish between 'principles' and 'causes':

... al that is termed a Principle out of or from which at first anything is, or is made known; but that a thing may be a cause it is necessary that it receives its Essence therefrom, and depend thereupon⁴⁷.

And the "forms", it appears, had the character of "principles", accounting for 'essential' features:

... the Forms themselves, as also the matter, were at the beginning of the world created with the things themselves, (that) of them all Natural things might consist:...⁴⁸.

Later, with an awkward double negation, he says:

For I do not hold with those who deny, that the first Qualities that are in the Elements do proceed from the forms of the said Elements, by way of Emanation, but derive them all from the motion of Heaven, or the Negation thereof. For 'tis an absurd thing, that a Natural Quality should proceed from any thing but its own Form⁴⁹.

Then, more positively, he continues:

Nor must we think the forms of the Elements are Lazy and Heartless, and produce no Qualities, nor work no operations. For if the first proceed not from the forms, which are most intimate with the Elements; I do not see what other Qualities can proceed from them: ...⁵⁰.

But what exactly, we may ask, did Sennert have in mind when he wrote of the "forms" of things? It is noteworthy that, when he attempted to give a more precise answer to this question he had to resort to the doctrine of "seminal principles", which was really more characteristic of the Stoic) Neo-Platonic tradition than of Aristotelianism. Thus, for example, in dealing with the problem of the cause of the properties of stones, Sennert wrote:

For every precious Stone hath its proper and specifick form whereby it is differentiated from al other, which it obtains from, (as I may say) its Seminal principle of Generation... so the Seminal principle of Jewels and Stones lies concealed in the Stone making matter; and in this darkness of our Minds its essence is unknown to us, as al other formes are; and their difference is not known save by the diversity of their faculties, operations and Qualities. For

⁴⁶ See: A. G. van Melsen, *From Atomos to Atom: The History of the Concept Atom*, Pittsburgh 1952, p. 81, ff.

⁴⁷ D. Sennert (1572—1637), *Thirteen Books of Natural Philosophy: ... Written in Latin and English, By Daniel Sennert, Doctor of Physick. Nicholas Culpeper, Physician and Astrologer. Abdiah Cole, Doctor of Physick, and the Liberal Arts*, London 1661, p. 11.

⁴⁸ *Ibid.*, p. 19.

⁴⁹ *Ibid.*, p. 87.

⁵⁰ *Ibid.*

upon this diversity of Forms, fit matter being Joyned thereto, depends the diversity of colours and external shapes⁵¹.

It seems, then, that in the period close to the eventual collapse of Aristotelianism men were coming to realise that they did not really know exactly what they were referring to when they used the term "form", yet, before the general espousal of the "mechanical philosophy", they had nothing better to put in its place. To borrow and modify a term from Kuhn, they were caught up in a "metaphysical revolution", casting around for some better basis of explanation, but not yet having found any suitable substitute. It may be noted that in Sennert's discussion, as in that of de Boodt before him, there is mention of properties and faculties flowing from the related forms, which is another reminder of the old overlap between logic and ontology, and possibly this continued to obscure the nature of the problem, even in the seventeenth century.

The distinction made by de Boodt between special characteristics which supposedly stemmed from "forms", and mundane features presumed to arise from material substance, reappeared from time to time during the course of the seventeenth century. The French academician, Jean Hellot, for example, asserted that:

... les corps composez ont plus ou moins d'action & de vertu, selon que plus ou moins ils participent des... principes: parce que tout vertu, action & puissance proviennent d'iceux, les elements vulgaires ne servans à autre chose, qu'à les vestir, couvrir & recevoir, n'estans d'eux mesmes que des corps morts & inutiles, sans odeur; saveur ny couleur, & incapables d'aucunes operations, sinon estant qu'ils sont meus & excitez par les principes qu'ils contiennent proprement toutes les actions, vertus, qualitez & proprietes qui se rencontrent les mixtes⁵².

Probably, however, the distinction made here did little to help the identification of the actual nature of an Aristotelian "form" or "principle".

Thus, as is well known, the Aristotelian doctrine of "matter" and "form" began to crumble irretrievably towards the middle years of the seventeenth century. It was succeeded by two distinct, yet overlapping, doctrines, both of which derived something from the earlier modes of explanation. I refer to the explanations of the "mechanical philosophers" such as Lemery and Hartsoeker, or the Newtonians, and the explanations of the German and Swedish "phlogistic" school of chemistry and mineralogy, later absorbed by chemists in France, England and elsewhere. These two categories were not, of course, mutually exclusive. The mechanicians made some use of chemical 'principles' such as mercury,

⁵¹ *Ibid.*, p. 143 (emphasis added).

⁵² J. Hellot, *Les élémens de la philosophie de l'art du feu ou chymie...*, 2nd edn., Paris 1667, p. 72.

oil, or salt, in their discussions⁵³; and the chemists, though often repudiating a simplistic utilization of the "mechanical philosophy", frequently made some use of "mechanical" models in their writings⁵⁴. In both cases, the doctrines employed what we have referred to as "reified essences". Thus, the variously shaped atoms or corpuscles utilized by the "mechanical philosophers", with their several motions, served as ultimate scientific explanations — the adoption of which, it has been said, is a characteristic feature of the essentialist approach. On the other hand, the chemists preferred to attribute the chemical properties of things to the natures of their chemical components. Stahl objected to the "mechanical philosophers" on the grounds that their proposed explanations were arbitrary and, as we might say, virtually unfalsifiable. But the same criticism might also be levelled at the Stahlian explanations. Stahl might decry the presumption that acidic properties were due to the presence of pointed spicules; but his own assertion that the "universal acid" was composed of water and a particular kind of "earth" was really just as arbitrary, and perhaps less intelligible. It should be noted, however, that the old Neo-Platonic and peripatetic "forms", now rejected by the philosophers, are to be found gathered together in the chemical principles of the theory of Becher and Stahl. This may readily be shown by looking at what Stahl had to say in his *Philosophical Principles of Universal Chemistry*.

Here he wrote:

The Form of Mixts is either generical, viz. that of Mixture itself; or specificical, viz. that of Mixts specifically different. The Generical is the combination of Principles numerically and essentially different, tho' not necessarily opposites. The Specificical, being unknown to the understanding, depends upon the different figure, number and situation of the material Principles [i.e., water and the three 'earths' of Becher]⁵⁵.

Thus Stahl is specifically ascribing the Form to the material Principles, and this identifies a direct link between the old peripatetic doctrine of "form" and the chemical essences of this eighteenth-century theory⁵⁶. It may be noted, however, that in referring to the "figure, number and situation" of the Principles Stahl is revealing some reliance upon doctrines normally associated with the "mechanical philo-

⁵³ See, for example: N. Lemery, *Cours de chymie...*, 2nd edn. Paris, 1677, 3 ff.; N. Hartsoecker, *Conjectures physiques*, Amsterdam 1706, p. 117, etc.

⁵⁴ See, for example: G. E. Stahl, *Experimenta, observationes, animadversiones, CCC numero, chymicae et pyhsicae*, Berlin, 1967. Here, Stahl depicts phlogiston as being made up of innumerable fine particles, with characteristic gyratory motions

⁵⁵ G. B. Stahl, *Philosophical Principles of Universal Chemistry: ... Drawn from the Collegium Jenense of Dr. George Ernest Stahl*. By Peter Shaw M. D., London 1730, p. 9.

⁵⁶ In the paper referred to above (note 3), I have drawn attention to the several utilizations of Aristotelian categories by Stahl in his *Philosophical Principles*.

sophy". We see, then, that in this Stahlian theory the essences have become fully reified, and the logical aspect of the doctrine of "form" has been discarded.

This new chemical doctrine, it can be said therefore, had roots in both the Neo-Platonic and the Aristotelian traditions. Two distinct types of essence, neither of which were thought of as being specifically material, were united in the chemical essences of the Stahlian theory. Or, we may say, this chemical theory had features whose antecedents are clearly recognizable in the philosophical traditions of Neo-Platonism and Aristotelianism.

I have suggested elsewhere that the essentialism of the eighteenth-century Stahlian chemists was largely suppressed by the "chemical revolution", though the notion of the conferring of properties by elements does survive in a somewhat modified form in the chemistry of Lavoisier⁵⁷. In general, however, Lavoisier's doctrines were much more positivistic in character than those of the Stahlians. But so far as Dalton's atoms were concerned, I suggest that they, like the earlier corpuscles of the Cartesians, had essentialist features. For Dalton, each element is linked with an atom of a particular kind and weight. The essence of a particular element, it seems to me, is now presumed to reside in its atoms, which served for Dalton as the ultimate basis of chemical explanation⁵⁸. Little wonder, then, that the positivist chemists of the nineteenth century sought to dispense with Daltonian atoms.

Finally, we may ask the question: Is it possible to construct a system of theoretical chemistry that does not seek to penetrate below the phenomenological level, to ultimate explanations, and which therefore can dispense entirely with theoretical entities of a property-conferring kind? It has, of course, been tried, and Ostwald's *Fundamental Principles of Chemistry*⁵⁹, with its emphasis on the establishment of chemical relations, without employment of hypothetical theoretical entities, probably comes as close to it as anything we are ever likely to see again. Yet this work seems quite strange to the modern reader, and I do not imagine that we shall ever see a return to chemical systems built up in this way. We do, today, make very considerable use of the notion of property-conferring principles, and, as I have attempted to show in this

⁵⁷ This point is discussed in my paper: *Mineralogy and the Chemical Revolution*, "Centaurus", 19 (1975), pp. 54—71.

⁵⁸ There is, however, the important difference that the atoms of Dalton were qualitatively different from the macrobodies of which they were presumed constituents. By contrast, the Stahlian inflammable "principle" (for example) was itself supposedly an expression of the quality of inflammability. "Principle" and property stood at the same qualitative level, so to speak.

⁵⁹ W. Ostwald, *The Fundamental Principles of Chemistry: An introduction to all text-books of chemistry*, New York 1909.

essay, such doctrines have a long and honourable history. The particular "principles" that were favoured in the eighteenth century have, of course, long been displaced, but we cannot, I think, dispense with some kind of reified essences in chemistry. Our electrons and protons have, deep down, their roots in the "forms" of Plato and Aristotle. And may we not steal a sentence from Richard Watson, and say, with respect to the neutrino, for example:

There are powers in nature which cannot otherwise become the objects of sense, than by the effects they produce; ... ?