A Commentary on
The Sceptical Chymist
of Robert Boyle
Vol. 2 of 2

by

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Introductory Remarks

The principal theme of this long chapter is, in the words of Boas (*q.v.*), 'that substances separated by fire are not always elementary.' Various chemical processes are described in which materials are separated by means of heat, and Carneades argues that the resulting decomposition products are not elementary. He offers the simple examples of burning wood, which decomposes into smoke and ashes and not into its elemental constituents, as smoke can be further decomposed into several separate substances. Wood ash, containing as it does potassium carbonate may, at a high temperature, be permanently combined into glass. This latter example demonstrates that heat may as well combine materials as decompose them (220-221).

Carneades offers further experimental evidence in support of the initial proposition by relating that further compounded bodies on heating are decomposed into products that are neither elementary, nor into the compound bodies constituting them, citing as examples: soap, lead acetate and iron sulphate (213-214).

He presents a Cartesian critique of the Paracelsians' understanding of the *tria prima* by arguing that they lack clear and distinct notions of them (202-203), and later presages Hume's Fork by advising that those Paracelsians who wish to write should either produce books that may teach the reader something, or else refrain from writing altogether (206-207).

The Sceptical Chymist

The Fourth Part

Carneades, having finished his discussion of the '*Number* of the Distinct substances from mixt Bodies by the Fire' (199.2-4), now proceeds to consider 'the *nature* of them, and shew [show] you, That though they seem *Homogeneous* Bodies, yet have they not the purity and simplicity [*i.e*. they do not have the purity and simplicity] that is requisite to Elements' (199.5-9). However, before moving on to do this, he must take issue with the Paracelsians and their lax use of language, when speaking of the elements. And this 'Confidence wherewith Chymists [Paracelsians] are wont [accustomed]' (199.12-13) to call substances sulphur, mercury or the other 'of the Hypostatical [elemental] Principles [*i.e*. salt]' (199.15-200.1), and also 'the intollerabln[1] Ambiguity they allow themselves ie[2] their writings and Expressions' (200.1-3) causes him both to avoid being mistaken by his interlocutor, or to prevent him from thinking that 'I mistake the Controversie [dispute]' (200.6-7) that he will 'take Notice [mention specially] to you and complain of the unreasonable Liberty they give themselves of playing with Names at pleasure' (200.7-10). He elaborates on this by saying that the above would cause him such confusion that he would hardly 'know how to dispute nor which way to turn my self' (200.18-19) if he were 'oblig'd [committed] in this Dispute, to have such regard to the Phraseology of each particular Chymist' (200.10-13) as to refrain from writing anything which such authors 'may not pretend, [allege *esp*. falsely] not to contradict this or that sence' (200.14-16) which they are liable to give to their 'Ambiguous Expressions' (200.17-18).

[1] Corrected to 'intolerable' in the *Errata*.
[2] Corrected to 'in' in the *Errata*.

Continuing with his diatribe, he explains what exactly the malefactors are doing by complaining that even 'Eminent Writers (such as *Raymund Lully,*[3] *Paracelsus* and others) do so abuse the termes they employ' (200.20-22) as sometimes they 'give divers [many] things, one name' (200.23-24) and frequently 'give one thing, many Names' (200.25), some of which may 'much more properly signifie some Distinct Body of another kind' (200.27-28). They even, he rails, take this 'Confounding [confusing] Liberty' (201.1-2) 'in Technical Words or Termes of Art [technical terms]' (200.29). He has seen that they will even 'call the same Substance, sometimes the Sulphur, and Sometimes the Mercury of a Body' (201.3-5). And having mentioned mercury, he 'cannot but take Notice [point out] that the Descriptions they give us of that Principle or Ingredient of mixt Bodies, are so intricate' (201.6-9) that even those 'that have Endeavour'd to Pollish and Illustrate the Notions of the Chymists [Paracelsians]' (201.10-12) are 'fain [willing]' (201.12) to admit that they do not know what it means, 'either by Ingenuous [clever] Acknowledgements [recognition of claims], or Descriptions that are not Intelligible' (201.13-16). Eleutherius now makes an interjection in which he remarks on the ambiguity of Paracelsus, and speculates as to its purpose. He says that in his reading of '*Paracelsus* and other Chymical Authors' (201.18-19), he has 'been troubled [perplexed] to find, that such hard Words and Equivocal Expressions' (201.19-21), even when writing of 'Principles, seem to be studiously affected by those Writers' (201.23-24).

[3] Ramon Lull/Llull (1232-1315/16) Catalan or Majorcean philosopher and Christian missionary to the Moors, and to whom a number of works on alchemy have been attributed.

He surmises that there are two possible reasons for this: one is to inflate the importance of their work, the second concerns the withholding of valuable information from their readers. As Eleutherius puts it, 'whether to make themselves to be admir'd by their Readers, and their Art [technical skill] appear more Venerable and Mysterious' (201.24-27), 'or (as they would have us think) to conceal from them a knowledge themselves judge inestimable' (201.27-30).

Carneades goes on to make a disparaging interjection regarding both the writers of such works and their readers. He states that in order to find approval among the uneducated, the writers are willing to risk being despised by the educated. He says that these writers 'may promise [commit] themselves from a Canting [jargon-laden] way of believing the Principles of Nature' (202.2-4), they can take advantage of the majority of the 'Knowing [learned] Men so vain' (202.5), when they do not understand what they are reading, that such readers 'conclude' (202.7) that the writers are to blame, and not themselves.

He then considers the writers 'that are so ambitious to be admir'd by the Vulgar [ignorant], that rather then [than] go without the Admiration of the Ignorant they will expose themselves to the contempt of the Learned' (202.9-13). This favouring of the approval of the uneducated over that of the learned Carneades dismisses contemptuously by saying that he will allow such writers to 'freely enjoy their Option' (202.14-15). He goes on to pass critical judgement on 'the Mystical [of hidden meaning] Writers scrupling [hesitating] to Communicate their Knowledge' (202.15-17), of whom he says that 'they might less to their own Disparagement [discredit] and to the trouble of their

Readers, have conceal'd it' (202.17-19) by writing no books, instead of bad ones. He continues by making an argument against the Paracelsians on behalf of Themistius by saying that 'if *Themistius* were here,[4] he would not stick [hesitate] to say, that Chymists write thus darkly [obscurely], not because they think their Notions too precious to be explain'd' (202.21-25), but rather that 'they fear that if they were explain'd' (202.25-26) the readers would see that 'they are farr from being precious' (202.27-28).

Carneades now employs a phrase undoubtedly borrowed from Descartes in which he discusses the clarity of the Paracelsians' notion of their three principles of salt, sulphur and mercury. He bluntly states his fear that 'the chief Reason why Chymists [Paracelsians] have written so obscurely of their three Principles, may be, That not having clear and Distinct Notions[5] of them themselves, they cannot write otherwise then [than] Confusedly of what they but Confusedly Apprehend' (202.28-29 – 203.6). He continues in this vein by making another comment critical of the work of his adversaries by suggesting another reason why they do not wish to deliver a clear expression of their teachings. He says that 'divers [many] of them, being Conscious to the Invalidity of their Doctrine' (203.6-8), realise that the only way to prevent it 'from being confuted [refuted]' (203.10) is by 'keeping themselves from being clearly understood' (203.10-12).

[4] This is a clear indication that Themistius has already parted company with Carneades and Eleutherius.

[5] The French philosopher René Descartes (1596 - 1650) argued that people often go wrong in their thinking because they rashly give their assent to propositions whose truth is not clear. However, provided they use their God-given power of reason correctly, assenting only to what they *clearly and distinctly perceive*, they can be sure of avoiding error.
See also: Descartes' *Meditations on First Philosophy* – The Fourth Meditation.

Carneades then offers a reason for forgiving the Paracelsians for not giving a clear account of their doctrines, and this is when they 'write Darkly and Aenigmatically, about the Preparation of their *Elixir*,[6] and Some few other grand *Arcana*,[7] the divulging of which they may upon Grounds Plausible enough esteem [consider] unfit' (203.13-18). This would seem to be a reference to Carneades declaring a certain sympathy for those who carry out practical alchemy, *i.e*. the attempted transmutation of base metal into gold or silver, a practice cloaked in secrecy by those who prosecute it, and in which Boyle himself had a considerable interest.

However, Carneades is far less sympathetic when those same practitioners 'pretend to teach the General Principles of Natural Philosophers [here: scientists] this Equivocall Way of Writing is not to be endur'd' (203.19-22). He explains that 'Mystical Termes, and Ambiguous Phrases' (203.27-28) are useless in making their 'Notion intelligible to me' (203.26-27) in those 'Speculative Enquiries, where the naked Knowledge of the Truth is the thing Principally aim'd at' (203.22-25). This, Carneades complains, places a double burden on him as a reader, in that in addition to 'examining the Truth of what he seems to deliver' (204.3-4), a writer such as this forces upon him 'the Trouble of guessing at the sence of what he Equivocally expresses' (204.1-2).

Carneades suggests to his adversaries that they could write clearly and openly of the behaviour of the majority of chemical operations without revealing their secret

[6] The elixir is a preparation by the use of which it is sought to change base metals into gold, sometimes identified with the Philosophers' Stone.
[7] The arcana were the supposed great secrets of nature which the alchemists aimed at discovering.

processes. He explains that, even allowing that the 'Philosophers Stone'[8] (204.5) and its preparation are 'such Mysteries as they would have the World believe them' (204.6-8), they may still 'Write Intelligibly and Clearly of the Principles of mixt Bodies in General, without Discovering [revealing] what they call the Great Work' (204.8-12). They seem to mean by this term their Arcana and Philosophers' Stone already referred to.

Carneades admits his distaste at the fanciful doctrines then current, by absolving himself from censure in disagreeing with any particular teaching not attributable to the well-known authorities. His reason is that he is already fully occupied in opposing the Paracelsian doctrine of the three principles, without having to spend time in opposing the writings of various other workers.

He says that 'what my Indignation at this Un-philosophical way of teaching Principles has now extorted [here: forced] from me' (204.13-15) is mainly to excuse himself if he should ever 'oppose any Particular Opinion or assertion' (204.17-18) which 'some Follower of *Paracelsus* or any Eminent Artist [here: alchemist]' (204.18-19) may pretend not to belong to his master. He has long since advised that his only requirement is to examine 'those Opinions about the *Tria prima*' (204.25-26), the three principles of salt, sulphur, and mercury, 'which I find those Chymists [Paracelsians] I have met with to agree in most' (204.26-27), rather than to expend endless time and effort in examining 'private mens writings' (204.22). Not that he will have to devote any great

[8] Although there is no simple definition of the 'Philosophers' Stone' it might be regarded as a substance which could transform, transmute, or perfect gross matter.

energy in countering the opinions put forward in such writings, as his 'Arguments against their [the Chymists or Paracelsians] Doctrine will be in great part easily enough applicable' (204.28-29 – 205.1) even to those other opinions which, he adds, 'they do not so directly and expressly oppose' (205.2-3).

Carneades goes on to make an argument in relation to the capacity of thermal decomposition to reduce compound bodies into their ultimate state of reduction. He says that in considering 'the things themselves whereinto *Spagyrists*[9] resolve mixt Bodies by the Fire' (205.5-7), it does not matter what they are called by the 'Chymists [Paracelsians]' (205.10) if he can 'shew [show] that they are not of an Elementary Nature' (205.8-9).

He continues with this line of thought by stating that the fact that a compound material can be thermally degraded into several decomposition products, does not necessarily mean that these products are elemental. He argues that 'Chymists [Paracelsians]' (205.18) cite 'Experience' (205.19) and point to the fact that 'several substances' (205.21) 'separated by the Fire from a Mixt Body' (205.21-22) does not constitute 'a sufficient proof of their being its component Elements' (205.22-24). These decomposition products may be regarded as compound materials and retain some, at least, of the properties of the bodies from which they are derived. Many such decomposition products are, he says, 'farr enough from Elementary simplicity, and may

[9] Those who take matter apart and put it together, a term attributed to Paracelsus. Alchemy was sometimes called the Spagyric Art.

be yet look'd upon as mixt Bodies' (205.25-27), retaining at least some of the properties of the 'Concretes [compound bodies] whence they were forc'd' (206.1).

Eleutherius congratulates his interlocutor for clipping the wings of his adversaries, expressing his pleasure at seeing 'the Vanity or Envy of the canting [jargon-laden] Chymists [Paracelsians] thus discover'd [revealed] and chastis'd' (206.3-4), and wishes 'that Learned Men would conspire together to make these deluding Writers sensible [*i.e.* make it clear to these deluding writers], that they must no longe[10] hope with Impunity to abuse the World' (206.5-9). He cites a lack of oversight, bordering on censorship, by which the truly knowledgeable might prevent those wrong-headed authors from publishing their works. This latter group, he pleads, are 'quietly permitted to publish Books with promising Titles' (206.9-11), in which they 'Assert what they please, and contradict others, and ev'n themselves as they please' (206.11-13), then adds humorously, 'with a little danger of being confuted [refuted] as of being understood' (206.13-15). He then adds pointedly that 'they are encourag'd to get themselves a name, at the cost of the Readers' (206.15-17), the reason for this being 'that intelligent Men are wont [accustomed] for the reason newly [just now] mention'd, to let their Books and Them[selves] alone' (206.17-20). He adds wearily that 'the ignorant and credulous' (206.20) – who are far more numerous than their opposites – 'are forward [eager] to admire most what they least understand' (206.22-24).

The remedy for this, Eleutherius avers sternly, is for such writers to be exposed for what they are, saying that 'if Judicious men skill'd in Chymical affaires shall once agree to

[10] Corrected to 'longer' in the 1680 edition.

write clearly and plainly of them' (206.24-26) so that the readers are not 'stunn'd, as it were, or imposed upon by dark or empty Words' (206.27-29).

Eleutherius believes that action such as this will prevent these writers from writing 'impertinently and absurdly, without being laugh'd at for doing so' (207.2-3), thereby forcing them 'either to write nothing, or Books that may teach us something' (207.4-5). It could be argued that Boyle is here foreshadowing 'Hume's Fork'.[11] Whereas Hume had in mind principally works on divinity and metaphysics, contrasting these with writings investigating mathematics or the natural world, Boyle's distinction between two types of works is no less harsh. His contrast is provided by advising aspiring writers either to write nothing, so as not to 'rob men, as formerly, of invaluable Time' (207.6-7) or to write works that may enlighten us. If this precept is adhered to by writers, they will cease 'to trouble the World with Riddles or Impertinencies', (207.7-8) and 'we shall either by their Books receive an Advantage, or by their silence escape an Inconvenience [absurdity]' (207.9-11).

Eleutherius now seems to row back from his attack on the Paracelsians by seeing some justification for the nomenclature they have generated in the course of their analyses of decomposition products. His argument is that those who discover something new should have the right to name it, as parents have the right to name their children. Somewhat surprisingly, he seems to make the point that those in the best position to inform the reader about any such materials are their discoverers.

[11] See Hume's *An Enquiry Concerning Human Understanding*, section 12, part 3. It might be noted that Hume was born in 1711 – some twenty years after Boyle's death.

He begins his account by saying that ‘it may be represented [claimed] in favour of the Chymists [Paracelsians]’ (207.13-14) that if they are to be excused the ‘Liberty they take in using names’ (207.15) it should be ‘when they speak of the substances whereinto their *Analysis* resolves mixt Bodies’ (207.17-19). He makes an analogy between the naming of both children and of new discoveries, by saying that as parents have the right to name ‘their own Children’ (207.20) ‘it has ever [always] been allow’d to the Authors of new Inventions, to Impose [bestow] Names upon them’ (207.20-22).

He continues that as such materials are produced solely by the efforts of the ‘Chymist’s Art’ (207.24-25), ‘it seems but [only] equitable to give the Artists [skilled practitioners] leave to name them as they please’ (207.26-28). He finishes by taking into account ‘that none are so fit [competent] and likely to teach us what those Bodies are, as they to whom we ow’d [acknowledged, esp. as belonging to oneself; = own] them’ (207.28-29.2). Carneades now interjects, quickly setting his interlocutor straight as to his reasoning, pointing out that it does not follow that the discoverer of something new necessarily has the capability of speaking authoritatively about it. He expresses this by arguing that ‘there is great Difference the being able to make Experiments, and the being able to give a Philosophical Account of them’ (208.4-7). The example he quotes is of a ‘Mine-digger’ (208.8) finding ‘a Gemm or a Mineral’ (208.9-10) unidentified by him, ‘till he shews [shows] it a Jeweller or a Mineralist’ (208.11-12). This example is straightforward in that a jewel may be unfamiliar to the person who has unearthed it, but an expert can identify it with certainty.

Carneades then goes on to say that his adversaries may validly apply names to the materials they produce in the course of their experiments, yet they must apply their terms consistently, and not say that a compound material is actually still a primary substance or that a non-flammable material is actually a form of an inflammable one. He argues that they undermine their credibility by speaking in such a contradictory manner. He says that what he 'would rather [preferably] have here observ'd' (208.13-14) is that the 'Chymists [Paracelsians]' (208.14) he is now in 'debate with have given up the Liberty you challeng'd [argued] for them, of using Names at Pleasure' (208.15-17) they have chosen for 'their Principles' (208.19). So far, so good, but they are entitled to call any of the products revealed by 'their *Analysis* [chemical decomposition]' (208.21) as 'either Sulphur, or Mercury, or Gas, or Blas[12] or what they pleas'd' (208.22-23). However, what Carneades finds incredible is when they define sulphur, for example, as 'a Primogeneal [elementary] and simple Body, Inflamable, Odorous, &c.' (208.25-26), and they go on to maintain that 'a Body that is either compounded or uninflamable is such a Sulphur' (208.28-29 – 209.1). He accuses them of playing with words when they 'teach that Gold and some other Minerals abound with an Incombustible Sulphur' (209.2-4), and is 'as proper an Expression, as a Sun-shine Night, or Fluid Ice' (209.4-6).

Having concluded his diatribe against the risible inconsistencies in the reasoning of his adversaries, Carneades now pauses to identify his position in the discussion. He says

[12] Blas is van Helmont's term for a supposed 'flatus' (a blast or breath) or influence of the stars, producing changes of weather.

that before moving on to his ‘Fourth Consideration’ (209.8-9) he decides that it is appropriate ‘to premise a few Generals’ (209.9-10), some of which he has already ‘Touched on’ (209.13) and will now ‘less need to insist [dwell at length on] on at present’ (209.11). He begins by drawing attention to ‘a certain passage in *Helmont*[13] which, although not ‘much heeded by his Readers’ (209.18-20) both Carneades and its author consider as significant.

He describes how ‘the Distill’d oyle of *oyle-olive*, though drawn *per se*[14] is (as I have try’d) of a very sharp and fretting [corroding] Quality, and of an odious [repulsive] taste’ (209.25-26 – 210.1-3). What Carneades seems to be describing here is the destructive distillation of olive oil, where the oil is heated to a sufficiently high temperature to cause it to boil and distil over, but that in so doing it undergoes at least partial decomposition with the production of unpleasant smelling (and tasting) decomposition products.

He continues that van Helmont relates how ‘Simple oyle being only digested with *Paracelsus’s sal circulatum*, is reduced into dissimilar parts, and yields a sweet Oyle’ (210.3-6). What he seems to mean is that when olive oil, composed mainly of oleic and palmitic acids, is reacted with a concentrated solution of alcohol, it reacts to form some sweet-smelling esters. These products he says are ‘very differing from the oyle

[13] Jan Baptista van Helmont (1588/89-1644) Flemish medic and chemist.
[14] That is, distilled by itself.

distill'd,[15] from sallet [salad] oyle [presumably olive oil]; as also that by the same way there may be separated from Wine a very sweet and gentle Spirit' (210.6-10).

This product may simply be a highly concentrated solution of alcohol, produced by repeated distillation of wine, and has 'a far other and nobler quality than that which is immediately drawn by distillation and call'd *Dephlegm'd Aqua vitae* [probably a less concentrated solution of alcohol]' (210.10-13), adding that 'from whose Acrimony [bitter pungency] this other spirit is exceeding remote' (210.13-15). What he may have been comparing were solutions of alcohol of differing strengths with the 'sweet and gentle Spirit' (210.9-10), being closer to pure alcohol – which itself has a very pleasant odour – than the '*Dephlegm'd Aqua vitae*' (210.13), which being weaker in strength did not have as pleasant an odour.

That the same starting material was employed in each example is acknowledged by Carneades who remarks that the '*sal circulatum* that makes these *Anatomies* [chemical analyses]' (210.15-16) is 'separated from the Analys'd Bodies, in the same weight and with the same qualities it had before' (210.16-18). Still cautious in accepting the testimony of van Helmont, Carneades says that 'if we admit to be true' (210.19-20), it must be acknowledged that there may be 'a very great disparity [between] bodies of the same denomination (as several oyles, or several spirits) separable from compound Bodies' (210.21-24).

[15] Comma removed in 1680 edition.

In addition, that Carneades is not here referring to the decomposition of compound bodies, but rather their reaction products with other materials, is clear by his saying that the differences he will 'anon [in a short while] take notice of' (210.25-26) ' [between] those distill'd Oyles that are commonly known to Chymists' (210.26-27). Van Helmont seems to be claiming that when his '*Sal Circulatum* [probably a concentrated solution of alcohol]' (210.29) is reacted with such a body, 'There may be quite another sort of Oyles obtain'd from the same Body' (210.29 – 211.1-2). In other words, reacting alcohol with certain materials results in the formation of a new set of products, as in the example just given of alcohol reacting with the acidic constituents of olive oil to form esters, which are chemical compounds quite distinct from the original oil and alcohol.

Carneades goes on to speculate that such other natural 'Agents' (211.3) may be discovered which may yield 'from the Bodies Vulgarly [commonly] call'd Mixt, Oyles or other substances, Differing from those of the same Denomination [designation], known either to Vulgar [common] Chymists, or even to *Helmont* Himself' (211.6-11). The mechanism by which such new material might be produced is acknowledged by Carneades as 'Transmutation or otherwise' (211.5-6). The veracity of van Helmont's account 'we have not the means to Experiment' (211.14-15) as it is based on 'another Man's Relation' (211.13). So Carneades 'will not Insist [stand on or upon] upon it' (211.15), instead choosing to move on to his next consideration.

He goes on to speculate whether 'the Opinion of *Leucippus, Democritus*,[16] and other prime [first] *Anatomists* [those who practice chemical analysis] of old' (211.19-20) and latterly revived 'namely, That our Culinary Fire, such as Chymists use, consists of swarms of little Bodies swiftly moving' (211.22-24), which 'by their smallness and motion are able to permeate the sollidest and Compactest Bodies' (211.25-27), including glass. Supporting evidence is given by the fact 'that In flints and other Concretes [compound bodies] the Fiery part is Incorporated with the Grosser' (211.29 – 212.1-2), by which Carneades seems to mean that, as flints generate sparks when struck against a hard surface, they seem to possess an inbuilt fiery component.

Carneades believes that, given the above, it is reasonable to conjecture that many such 'Fiery Corpuscles, getting in at the Pores of the Glass, may associate themselves with the parts of the mixt Body whereon they work' (212.3-7), combining with them to 'Constitute new Kinds of Compound Bodies' (212.7-8), 'according as the Shape, Size and other Affections [properties] of the Parts of the Dissipated [dispersed] Body happen to dispose them, in Reference to such Combinations' (212.9-12), which themselves may be numerous. It may also be assumed that all the fast moving, minute 'Corpuscles of the Fire' (212.15) 'are not all of the same bigness, nor Figure' (212.17-18).

He now refers to experimental evidence 'to Countenance [bear out] what I have newly [only just] said' (212.20-21), which leads to his deducing 'that the Particles of the open Fire' (212.23-24) may combine with some reactants, adding to their weight. He will not

[16] Leucippus was a 5th century BCE Greek philosopher, and originator of the atomic theory, the details of which have come down through his follower Democritus.

now supply details of such evidence as he has 'Weightier Considerations to Discourse [discuss] to you of' (212.18-19). What he is not so sure of is that when fire acts on the constituents of glasses 'it does it by a reall Trajection [passage] of the Fiery Corpuscles themselves, through the Substance of the Glass' (212.29 – 213.1-3) This is possibly a reference to earlier experiments in which he attempted to incinerate some organic samples through glassware associated with his air-pump, by focusing the rays of the sun on the samples by means of a magnifying glass.[17]. His doubt on the subject prompts him to proceed to the next topic for discussion.

Eleutherius comes to the aid of his interlocutor by adducing 'some Proofes' (213.6) of the high probability that when 'the Fire acts immediately [directly] upon a Body, some of its Corpuscles may stick to those of the burnt Body, as they seem to do in Quicklime, but in greater numbers, and more permanently' (213.8-12). What Eleutherius seems to be referring to is the preparation of lime or calcium hydroxide, which is produced by adding water to quicklime or calcium oxide, with the liberation of a considerable amount of heat. The quicklime is itself produced by burning limestone, impure calcium carbonate, in a lime-kiln. Eleutherius seems to regard the heat generated during the slaking of the quicklime as due to the particles or corpuscles of fire still adhering to it. Not wishing to retard 'Your Progress' (213.13) he requests Carneades to deferr this Enquiry till another time' (213.14-15) and continue as he had intended.

[17] These experiments are reported in his *New Experiments Physico-Mechanical, Touching the Spring of the Air and its Effects*. See: Hunter and Davis, eds. *The Works of Robert Boyle*, 1:191.

Carneades invites Eleutherius to 'observe with me, that not only there are some Bodies, as Gold, and Silver, which do not by the usual Examens [investigations], made by Fire, Discover [reveal] themselves to be mixt' (213.18-22), but that, as he has already related, 'it be a De-compounded [further compounded] Body that is Dissipable [dispersible] into several Substances' (213.23-25). It may by thermal decomposition 'be resolv'd into such as are neither Elementary' (213.26-27), nor into those materials 'it was upon its last mixture Compounded of' (213.28-29), but rather 'into new Kinds of mixts' (213.29 – 214.1). He has already given as examples 'Sope, Sugar of Lead [lead acetate], and Vitrioll [ferrous sulphate]' (214.2-3).

He goes on to say that in addition to the natural product 'last nam'd' (214.5-6) there are also materials that are 'Factitious [artificial], manifestly [unmistakably] Decompounded [further compounded]' (214.6-7). We see that sometimes 'in the Bowells of the Earth Nature may' (214.7-8) 'make strange Mixtures' (214.9-10). He continues that 'Animals are nourish'd with other Animals and Plants' (214.10-11) and that almost all of these take 'their Nutriment and Growth' (214.13) from a limited number of sources, which Carneades lists as: '*either* from a certain Nitrous [containing nitre or potassium nitre] Juice Harbour'd in the Pores of the Earth' (214.13-15), 'or from the Excrements of Animals, or from the putrify'd Bodies, either of living Creatures or Vegetables' (214.15-18), 'or from other Substances of a Compounded Nature' (214.18-19).

These examples serve as evidence in support of Carneades' contention that materials, both natural and synthetic, may be composed not of simple ingredients but rather of starting materials which are themselves compound. He says that there may be, in fact, 'a greater Number of De-compound Bodies [further compounded bodies], then [than] men take Notice of' (214.23-25). Moreover, Carneades reiterates, 'it does not at all appear, that all Mixtures must be of Elementary Bodies' (214.26-28), as it is much more likely that several kinds of compound materials 'even [namely] in regard of all or some of their Ingredients, consider'd Antecedently [previously] to their Mixture' (215.1-3).

Carneades elaborates on this by saying that although some compound materials 'seem to be made up by the immediate [close] Coalitions of the Elements' (215.4-6), or principles, 'and therefore may be call'd *Prima Mista* [primary mixtures] or *Mista Primaria* [mixtures of the first order]' (215.6-8), it still seems that many other materials are mixed 'at the second hand' (215.10), with 'their immediate [close] Ingredients being not Elementary, but these primary Mixts newly [recently] spoken of' (215.10-13). More complex materials may also be prepared when from 'divers [many] of these Secondary sort of Mixts may result, by a further Composition, a Third sort, and so onwards' (215.13-16). It is likely that some compound materials may consist of ingredients of different levels of complexity, or indeed 'not all of the same Order, but of several' (215.18-19), one ingredient 'may have been a primary, the other a Secondary Mixt Body' (215.21-22). Carneades quotes as example 'Native Cinnaber [mercuric sulphide]' (215.23), which by his method 'of Resolving [separation into constituent parts] it, found both that Courser the[18] part that seems more properly to be Oar, and a Combustible Sulphur, and a Running Mercury' (215.23-27). Carneades understands that cinnabar, or mercuric sulphide, is a metal ore, which consists of two distinct

[18] This 'the' removed in *Errata*.

materials: mercury and sulphur, and which as mined would be quite coarse. When this is heated with, for example, charcoal, the ore is reduced to liquid mercury, with the sulphur present burning off.

He lists another possibility, *viz*. ‘without any Ingredient of this latter sort’ (215.27-28), that is, not consisting of a primary and a secondary compound body, but rather consisting of the ‘first, and some of the third Kind’ (216.1-2), meaning compound materials consisting of a primary and a tertiary compound body. Carneades cites as examples ‘some Chymical Preparations of those Medicines which they call their *Bezoardicum’s*’ (216.4-6), by which he probably means various medicinal preparations, intended for use as counterpoisons or antidotes. These are prepared by taking ‘Antimony and Iron, which may be look’d upon as *Prima Mista* [primary mixtures]; of these they compound a Starry *Regulus*’[19] (216.7-9), adding to this, as required, ‘either Gold, or Silver, which makes with it a new and further Composition’ (216.11-13). He continues that ‘to this they add Sublimate [mercuric chloride] which is itself a De-compound [further compounded] body, (consisting of common Quicksilver [mercury], and divers [various] Salts united by Sublimation into a Crystalline Substance)’[20] (216.13-17). He goes on to say that ‘from this Sublimate [mercuric chloride], and the other Metalline Mixtures, they draw a Liquor, which may be allow’d [acknowledged] to be of a yet more Compounded Nature’[21] (216.17-21).

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[19] Antimony on cooling forms long, slender crystals, which may arrange themselves into particular shapes, sometimes forming stellar patterns.

[20] Mercuric chloride can be prepared by, for example, heating a mixture of mercuric sulphate with common salt, giving the volatile mercuric chloride, which condenses into a crystalline form.

[21] Mercuric chloride can be reacted with mercury metal to form mercurous chloride, or calomel.

Carneades relates the claim 'as Chymists affirm it, that by this Art some of the Gold or Silver mingl'd with the *Regulus* [antimony] may be carry'd over the Helme [head of a retort] with it by the Sublimate [mercuric chloride]'[22] (216.22-25). Carneades explains that 'a Skillful and Candid [impartial] person complain'd to me a while since [ago], That an experience'd Friend of His and mine, having by such a way brought over a great Deal of Gold' (216.26-29 – 217.1), but was 'unable to recover his Volatiliz'd Gold out of the Antimonial butter[23] wherewith it is strictly [closely] united' (217.4-7).

What may have happened here is that some of the antimony trichloride decomposed in the presence of water, and the chloride thereby liberated reacted with the gold to form auric chloride. Hence the experimenter's frustration at not being able to recover his gold in metallic form.

He next argues that the decomposition products of a compound body, itself composed of compound ingredients, may themselves be of a compound nature. He states that the decomposition products of a 'Compound Body' (217.9), consisting of 'Ingredients that are not meerly [purely] Elementary' (217.9-10) although themselves 'seemingly Homogeneous enough, may be of a Compounded Nature' (217.13-15). What Carneades seems to believe is that such decomposition products are not necessarily inert, but may in fact react with one another, 'those parts of each body that are most of Kin [having

[22] This may be a reference to a version of a process by which gold may be separated from silver. Gold was separated from silver by fusing with stibnite [antimony sulphide] or antimony, in a crucible and pouring into a greased iron cone, when the gold settled to the bottom, and the upper part, on cupellation [oxidisation in a current of air], gave silver, with a little loss.
See Partington, *History of Chemistry*, 2:19.

[23] Butter of antimony was the name given to the fatty mass of antimony trichloride.

common attributes] Associating themselves into a Compound of a new Kind' (217.15-17).

Carneades goes on to give an actual example: he 'Caus'd Vitrioll [ferrous sulphate] and *Sal Armoniack* [ammonium chloride], and Salt Petre [nitre or potassium nitrate] to be mingl'd and Destill'd together' (217.18-20), and found that 'none of these would dissolve crude gold, which yet my Liquor was able readily to do' (217.24-26). From this property it 'thereby manifested [revealed] it self to be a new Compound' (217.26-27), inferring that it consists 'at least of Spirit of Nitre [nitric acid], and *Sal Armoniack* [ammonium chloride]' (217.27-28), adding – correctly – '(for the latter dissolv'd in the former, will Work on Gold)[24] (217.29 – 218.1), and although these ingredients when mixed together form a solvent capable of dissolving gold, they 'nevertheless are not by any known way separable' (218.1-3). From this he infers that it 'consequently would not pass for a Mixt Body, if we our selves did not, to obtain it, put and Distill together divers Concretes [compound materials], whose Distinct [separate] Operations were known before hand' (218.3-7). Carneades is here arguing that a substance cannot be taken as elementary simply because no known method is capable of decomposing it. He happens to know that one such material – one synthesised by himself from known starting materials, and itself an active substance – is, in reality, a compound material.

He then relates an experiment, already promised, again with the intention of demonstrating that an alleged elementary substance may be obtained from the reaction

[24] Carneades is here giving a method for producing *aqua regia* by dissolving ammonium chloride in nitric acid. Otherwise it may be prepared by mixing 1 part of nitric and 4 parts of hydrochloric acids.
See also: Partington, *History of Chemistry*, 2:36.

of two materials themselves believed to be elementary. He narrates how 'suspecting the Common Oyle of Vitrioll [sulphuric acid] not to be altogether such a simple Liquor as Chymists presume it' (218.12-14), he mixed it with an equal or 'Double Quantity' (218.15) 'of common Oyle of Turpentine[25] such as together with the other Liquor I bought at the Drugsters'[26] (218.17-19). These he carefully distilled in a small glass retort, noting that 'the Experiment is Nice [delicate or careful in manipulation] and somewhat dangerous' (218.20-21).

Carneades obtained 'according to my Desire, (besides the two Liquors I have put in) a pretty [considerable] Quantity of a certain substance' (218.23-26), 'which sticking all about the Neck of the Retort Discover'd [revealed] it self to be Sulphur' (218.26-28). He confirmed that it was indeed sulphur by 'a very strong Sulphureous smell, and by the colour of Brimstone [sulphur]' (218.28-29 – 219.1), and, in addition, when it was 'put upon a coal, it was immediately kindl'd [ignited], and burn'd like common Sulphur' (219.2-4). He retained 'some little Parcells' (219.5), which Eleutherius 'may command [have at his disposal] and examine' (219.6) at his pleasure.

That Carneades obtained sulphur in this experiment there can be little doubt, what is more uncertain is how. He says that as reaction products he obtained 'the two Liquors I had put in' (218.24-25). Does he mean that these were unchanged and unreacted? If so, perhaps there was some free sulphur which separated out during distillation, and present

[25] This is a volatile oil contained in the bark, leaves and other parts of coniferous trees, and usually prepared by distilling crude turpentine.
[26] A drugster is a person who prepares and dispenses medicinal drugs, *i.e*. a pharmacist.

as an impurity in the sulphuric acid.[27] Hot turpentine dissolves sulphur, so what may have happened is that during the distillation process the free sulphur dissolved in the boiling turpentine, and as this vaporised and passed over into the condenser any sulphur entrained in it was deposited around the neck of the retort.

In any event, Carneades deduces one or both of the following propositions: 'That a real Sulphur may be made by the Conjunction of two such Substances as Chymists take for Elementary, and which did not either of them appear to have any such body in it' (218.9-14). Carneades is arguing that if neither body seems to have sulphur present in it, then any sulphur formed in the course of their reaction must result from the reaction of the two reactants, and if this is indeed the case, then sulphur cannot be a simple elementary body, but rather a compound material.

His second proposition raises the possibility that 'Oyle of Vitrioll [sulphuric acid] though a Distill'd Liquor, and taken for part of the Saline [here: not flammable] Principle of the Concrete [compound material] that yields it, may yet be so Compounded [composite, complex] a body as to contain, besides its Saline part, a Sulphur like common brimstone [sulphur]' (219.14-20). He adds mischievously – in direct opposition to the Paracelsians considering it to be one of their principles – that such a body 'would hardly be it self a simple or un-compounded body' (219.20-22).

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[27] An early method for the production of sulphuric acid was by igniting a mixture of sulphur and potassium nitrate in large glass bells or jars. This process would probably result in the presence of some free sulphur in the sulphuric acid thereby formed.

That there may be an indeterminate number of elements, with different compound materials consisting of different elements, is suggested by Carneades. He reminds his companion that he has earlier 'represented [asserted] it, as possible, That as there may be more elements then [than] five, or six; so the Elements of one body may be Different from those of another' (219.24-28). This means 'that from the Resolution [separation into constituent parts] of Decompound Body'[28] (219.29 – 220.1), that is, bodies which themselves consist of compound ingredients. Such compound ingredients may not separate out precisely into their original constituents, but instead may reassemble into new materials, resulting in the production of 'Mixt [compound materials] of an altogether new kind, by the Coalition of Elements that never perhaps conven'd [came together] before' (220.1-4).

Carneades could continue to discuss his second proposition, but 'for fear of wanting [lacking] time I willingly pretermit [omit] them' (220.6-7), and present his third: 'That the Fire does not always barely [simply] resolve or take asunder, but may also after a new manner mingle and compound together the parts (whether Elementary or not) of the Body Dissipated [dispersed] by it' (220.9-14). He says that the validity of this preposition is so evident 'in some obvious Examples' (220.15-16) that he 'cannot but wonder at their Supiness [lack of interest] that have not taken notice of it' (220.16-18). Carneades goes on to explain exactly what he means, by recalling Themistius' account of the burning of wood, whereby the Aristotelian explanation of the revealing of their four elements – earth, air, fire and water is related by him on p. 21. Carneades states that 'when Wood being burnt in a Chimney is dissipated [dispersed] by the Fire into

[28] Corrected to 'bodies' in the *Errata*.

Smoke and Ashes, that smoke composes [produces] soot' (220.18-21), whereas in Themistius' account he saw the smoke as 'readily vanishing into air' (please note: 21.20). The soot, Carneades continues, 'is so far from being any one of the principles of the Wood' (220.21-23) that, as he has already noted, 'you may by a further *Analysis* [decomposition] separate five or six distinct substances from it' (220.24-25). Not only that, but 'the remaining Ashes, the Chymists themselves teach us, that by a further degree of fire they may be indissolubly united into glass'[29] (220.26-29).

He answers the potential objection that the analysis 'which the Chymists principally build upon is made, not in the open air, but in close [closed] Vessels' (221.1-3), by saying that his recent examples may invite one 'shrewdly [astutely] to suspect, That heat may as well compound as dissipate [disperse] the Parts of mixt Bodies' (221.5-7). He goes on to mention 'a Vitrification [production of a glassy material] made even in close [closed] vessels' (221.8-9), and reminds his interlocutor that 'the Flowers of Antimony [antimony trioxide] and those of Sulphur, are very mix'd Bodies, though they ascend in close [closed] Vessels' (221.9-12). These two materials are produced by vaporising the minerals in question, and condensing the vapours onto cooler parts of the apparatus. A further example is provided by Carneades when he relates that ''twas in stopt [stoppered] glasses that I brought up the whole Body of Camphire [camphor]' 221.12-14).

[29] A reference to the potash, or potassium carbonate present in wood ash, which can be employed in the preparation of glass – itself a highly inert material.

Carneades offers an objection to the examples just given which hinges on the fact that the materials in question have evaporated and condensed to form a solid rather than a liquid. He states that 'it may be objected, that all these Examples are of Bodies forc'd up in a dry, not a Fluid forme' (221.14-17), like the 'Liquors wont [habitually] to be obtain'd by distillation' (221.17-18). His reply to this objection is that 'besides that 'tis possible' (221.19), that is, besides distillation, 'That a Body may be chang'd from Consistent [solid] to Fluid' (221.20-21), or the other way around, 'without being otherwise much altered' (221.22-23), quoting as an example, the ease with which, in winter, 'without any Addition or Separation of Visible Ingredients, the same substance may be harden'd into brittle Ice and thaw'd again into Fluid Water' (221.24-28).

His next example is that of mercury, 'which the Eminent Chymists confess to be a mixt Body' (222.1-2), and which 'may be Driven over the Helme [head of a still] in its Pristine [original] forme of Quicksilver [mercury], and consequently, in that of a Liquor' (222.3-5). Intriguingly, by way of an aside, he says that he has been able 'by the help of a certain *Menstruum* [solvent], to distill Gold it self through a Retort, even with a Moderate Fire'[30] (222.9-11).

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[30] The fact that a *moderate* fire was employed means that Carneades did not distil pure metallic gold, as this metal, boiling point 2807^{o}C, would require a very hot fire indeed to distil it.

Carneades' *Menstruum* or solvent may have been what he calls *aqua regia* – a mixture of nitric and hydrochloric acids, which dissolves gold to form auric chloride. Principe details a process by which this compound may be caused to sublime, or volatilise, and this seems to be what Carneades is referring to here.
See also: Lawrence M. Principe. *The Secrets of Alchemy*. (Chicago: University of Chicago Press, 2013), 151-152.

What Carneades really wishes to discuss is ‘what happens in Butter of Antimony [antimony trichloride]’ (222.12-13), saying that ‘if that be carefully rectify’d [distilled], it may be reduc’d into a very clear Liquor’ (222.13-15), ‘and yet if you cast a quantity of fair [clean] water upon it, there will quickly precipitate a Ponderous [heavy] and Vomitive [causing vomiting] Calx [metal oxide]’ (222.15-18). What he is referring to here is the addition of water to the colourless antimony trichloride, leading to the formation of antimony oxychloride, or antimony chloride, which is a white powder. Carneades says that this material forms a bulky precipitate when water was added to the original antimony trichloride, by explaining that: it ‘made before a considerable part of the Liquor’ (222.18-19). It is, he believes, an antimony compound (and not as ‘some eminent Chymists’ (222.20) believe, a mercury compound) which is somehow present in the butter of antimony or antimony trichloride, even during its rectification or distillation, and is ‘carryed over and kept dissolv’d by the Salts of the Sublimate’ (222.22-23). He infers from this behaviour that it is indeed an antimony compound, as one can confirm ‘if You will have the Curiousity to Examine this White powder by a skilful Reduction’ (222.25-27). He seems to mean by this that if antimony oxychloride is heated in the presence of a carboniferous fuel it will be reduced to antimony, which is of course, true.

What Carneades next seems to wish to emphasise is his skill in distilling non-volatile materials, and his companion may believe that ‘Bodies as compounded [complex] as flowers of Brimstone [sulphur] cannot be brought to Concurr [flow together] to Constitute Distill’d Liquors’ (222.28 – 223.2). Such a belief is shared ‘with Divers

[many] Learned Men' (223.3), well versed in 'Chymistry' (223.4), who hold 'that at least no mixt body can be brought over the Helm [head of a still], but by corrosive Salts' (223.5-6), probably meaning by reaction with strong mineral acids. Carneades will demonstrate, by request, 'among other ways of bringing over Flowers of Brimstone [sulphur condensed from the vapour]' (223.8-9), and perhaps 'even Mineral Sulphurs' (223.10), by which he may mean the sulphur which is a constituent of several metal ores, or of sulphate minerals. He goes on to say that there are 'some wherein I employ none but Oleaginous [oily] bodies to make Volatile Liquors' (223.10-12). Sulphur, though insoluble in water, does dissolve in some oils, 'in which not only the colour' (223.12-13), but the odour 'and some Operations manifest [show] that there is brought over a Sulphur that makes part of the Liquor' (223.14-17). Carneades seems to mean that, in addition to colour and odour, some other tests, perhaps such as burning the oily sulphur-rich distillate, indicate that it does indeed contain sulphur.

Carneades wishes to note something already mentioned but which is 'so pertinent to my present purpose' (223.19-20), in which he turns the Aristotelian understanding of the constitution of material bodies against the Paracelsians. He applies the Aristotelian interpretation of materials as consisting of substance and accident, by arguing that the material or substantial portion of a body is common to all material entities, and that bodies are differentiated by accidental properties, that is to say, distinguishing features not inherent in matter itself. This being the case, no materials can be considered as privileged, including the Paracelsian principles of salt, sulphur and mercury, as accidental change to matter, resulting through the agency of heat, may lead to the formation of a new body.

He argues 'That the Qualities or Accidents, upon whose account Chymists are wont [accustomed] to call a portion of Matter by the name of Mercury or some other of their Principles' (223.23-27), 'are not such but that 'tis possible as Great [important]' (223.27-28) materials and others like them, may be produced by 'such changes of Texture [physical structure], and other Alternations' (223.29 – 224.1) as Fire may bring about in the microstructure of the material. In support of his argument Carneades states that he has already proven when discussing his 'second General Consideration' (224.4-5) that 'Nature is able to effect as great Changes as a parcell of Matter reputed similar, as those requisite [appropriate] to Denominate [name] one of the *Tria Prima*' (224.9-12). This she does in the case of 'plants nourish'd only with fair [clean] water, and Eggs hatch'd into Chickens' (224.5-7) simply 'by changing the disposition [relative position] of the component parts of a Body' (224.7-9).

He goes on to relate that although van Helmont refers somewhere to fire as 'the Destructor and the Artifical Death of Things' (224.14-15), with 'Another Eminent Chymist and Physitian [physicist]' (224.16-17) contributing to this 'That Fire can never generate any thing but Fire' (224.18-19). Yet, he says, his companion will have a different opinion on this matter if he considers 'how many new sorts of mixt Bodies Chymists themselves have produc'd by means of the Fire' (224.20-23). He cites, in particular the production of 'that Noble [not destroyed by fire] and Permanent Body, Glass' (224.24-25), 'by the violent action of the Fire' (224.26), adding correctly, that 'for ought [aught] we know' (224.27) has never been produced by any other means. Some Helmontians make the 'inconsiderate [unconsidered] Assertion' (224.29) 'that every sort of Body of a Peculiar [distinctive] Denomination [name] must be produc'd by some Seminal power [the power of producing offspring]' (225.1-3). The necessity to continue with his 'discourse' (225.6) prevents him from delaying to 'evince [overcome]' (225.4) this assertion.

Carneades now poses a question of considerable significance to his investigative enterprise: how does one distinguish between natural and artificial materials, correctly noting that their production through the agency of the fire does not discriminate between the two. He states, firstly, that there are those who consider the materials produced by fire 'not as upon Natural but Artificial Bodies' (225.9-10). He avers that 'there is not alwaies such a difference as many imagine [between] the one and the other' (225.11-13). The differences that do subsist between materials are difficult to specify or determine, as it is not 'so easy as they think, clearly to assigne that which Properly, Constantly, and Sufficiently, Discriminates them' (225.13-16).

He goes on to discuss the distinction between artificial objects as produced by the human hand and the entities synthesised in the laboratory. A thing is generally held as artificial, he argues, when some matter 'is by the Artificers [craftsman's] hand, or Tools, or both, brought to such a shape or Form, as he Design'd before-hand in his Mind' (225.20-23). By contrast, he continues, in many chemical reactions 'the effect would be produc'd whether the Artificer [here: scientist] intended it or no' (225.24-26). And especially in the case of what are now considered chemical reactions of *organic chemicals*, he correctly understood that the result 'is oftentimes very much other then [than] he Intended or Look't for' (225.26-28).

He explains that 'the Instruments employ'd, are not Tools Artificially fashion'd and shaped' (225.28-29 – 226.1) as would a tradesman's, but rather are generally 'Agents of Nature's own providing' (226.3-4), and it is from their own 'Nature or Texture, not the Artificer [scientist]' (226.6) that they obtain their principal 'Powers of Operation' (226.4-5). Carneades goes on to say that 'the Fire is as well [as much] a Natural Agent as Seed' (226.7-8). In employing fire, the chemist is doing no more than bringing together 'Natural Agents and Patients [passive recipients]' (226.9-10), which when brought together, 'and acting according to their respective Natures, performe the worke themselves' (226.11-13). This he likens to the production of fruits which 'are natural Productions' (226.14), even though the gardener facilitates the production of fruit when he, among other operations, binds together the 'Sciens [shoots] of the Stock [trunk or stem]' (226.16).

Moving on from this diversion, he reiterates that 'Qualities sleight [slight] enough may serve to Denominate [designate] a Chemical Principle' (226.22-23), meaning that a quality need only bear a passing resemblance to one of the *tria prima* of salt, sulphur and mercury for it to be considered as one of these by the Paracelsians. When they 'anatomize [analyse] a compound Body by the Fire', (226.24-25), if the product is inflammable and insoluble in water, ‘they presently [immediately] call Sulphur’ (226.27), if it ‘is sapid [having a decided taste or flavour] and Dissoluble [insoluble] in Water, that must passe for Salt’ (226.28-29), and ‘Whatsoever is fix’d [inert] and indissoluble [insoluble] in Water, that they name Earth’ (226.29 – 227.2). He adds in exasperation that ‘whatsoever Volatile substance they know not what to make of, not to say, whatsoever they please, that they call Mercury’ (227.3-6). What Carneades seems to be saying is that, not only volatile substances, but also the ones that cannot easily be categorised or classified, many of which have an odour, would with little consideration, be counted as mercury.

He offers an objection to this line of reasoning by quoting the example of glass, which is produced by subjecting sodium or potassium carbonate, mixed with white sand (itself consisting mainly of silica) and lime, to a very high temperature. He makes a second objection by arguing ‘that these Qualities may either be produc’d, otherwise then [than] by such as they call Seminal Agents [seeds or germs]’ (227.6-8).

In relation to glass he says that ‘in Glass made of ashes’ (227.11), wood ash being a source of potassium carbonate, ‘where the exceedingly strongly-tasted *Alcalizate* [alkaline] Salt’ (227.11-13), *i.e*. the potassium carbonate and lime mixture, ‘joyning with the Earth [here: the sand] becomes insipid’ (227.13-14), that is to say, in forming the glass they lose their original taste and adopt a neutral taste and odour, ‘and with it constitutes a Body, which though also dry, fixt [inert], and indissoluble [insoluble] in

Water, is yet manifestly [obviously] a mixt Body; and made so by the Fire it self' (227.14-17).

Carneades says that he can 'remmember[31] to our present purpose' (227.18-19) van Helmont's description for the production of one particular medicine, the details of which, though 'but obscurely intimated' (227.22) he will not 'Dis-believe the Process' (227.23-24) although neutral as to the 'vertues of the remedy' (227.25) thereby prepared.

This account may be translated as:

> 'When (sayes he) cinnamon oil, etc, is mixed with its alkali salt without any water, through skilful and secret distillation for three months all of it is converted into a volatile salt. Indeed the essence of its simplicity is expressed in us, even as far as obtruding itself into our fundamental constitution' (227.26-29 – 228.1-3).[32]

Van Helmont gives a similar process elsewhere which, if credible, Carneades may argue, that since fire may produce a material which is 'as well [as much] Saline and volatile as the Salt of Harts-horn [ammonium carbonate], blood [ammonia], &c. which pass for Elementary' (228.8-10), and since 'this fugitive Salt is really compounded of a Chymical Oyle and a fixt [inert] Salt' (228.10-12) which react together to make 'the one made Volatile by the other, and both associated by the fire' (228.12-14), then the action of the fire in causing these two materials to react together, allows Carneades to suspect

[31] Corrected to 'remember' in the 1680 edition.

[32] ' *Quando* (sayes he) *oleum cinnamomi &c. suo sali alkali miscetur absque omni aqua, trium mensium artificiosa occultaque circulatione, totum in salem volatilem commutatum est, vere essentiam sui simplicis in nobis exprimit, & usque in prima nostri constitutiva sese ingerit*.'

'that other Substances emerging upon the Dissipation [dispersion] of Bodies by the Fire, may be new sorts of Mixts, and consist of Substances of differing natures' (228.15-18).

He goes on to speak of the connection between the odour of chemical products and the identity ascribed to them, in particular linking strong, especially unpleasant-smelling materials, with sulphur, many of the compounds of which have obnoxious odours. He says that he has 'sometimes suspected, that since the Volatile Salts of Blood, Harts-horn, &c' (228.19-21), by which he may mean either ammonium carbonate or ammonia itself, 'are figitive[33] and endow'd with an exceeding strong smell' (228.21-22), then there are two possibilities: 'either that Chymists do Erroneously ascribe all odours to sulphurs' (228.23-24), which would provide them with an explanation as to why many chemical compounds are odoriferous. Alternatively, he conjectures 'such Salts consist of some oyly parts well incorporated with the Saline ones' (228.24-26), by which he may mean that the oily component of the material is volatile and causes such products to smell as strongly as they do.

He continues that he has also considered 'Spirit of Vinager [acetic acid]' (228.28) though 'the Chymists think one of the Principles of that Body' (228.29 – 229.1), 'and though being an Acid Spirit it seems to be much less of kin [related] then [than] Volatile Salts to sulphurs' (229.1-3), then there is 'its piercing smell' (229.4), which is vinegar-like. He says that 'I know not with what congruity [correspondence of structure] the Chymist will deduce from Salt' (229.4-6), by which he seems to mean that its acidic nature would cause it to be classified as a salt, despite its pungent odour, which would

[33] Corrected to 'fugitive' in the *Errata*.

allow it to be considered as a sulphur. He chides them for not having 'taken notice of what their own *Tyrocinium Chymicum* [Chemistry for Beginners] teach us concerning the Destillation of *Saccharum Saturni* [lead acetate]' (229.7-10).

Carneades related how out of this product '*Beguinus*[34] assures Us, that he distill'd, besides a very fine spirit, no lesse then [than] two Oyles, the one blood-red and ponderous, but the other swimming on top of the Spirit, and of a yellow colour' (229.10-14), some of which he retains for verification. He recounts that he himself does not recall having had 'two distinct Oyles from Sugar of Lead [lead acetate]' (229.18-19), yet acknowledges 'that it will though distill'd without addition yield some Oyle, disagrees not with my Experience' (229.19-22). The oil referred to here seems to be the red liquor, called 'fixed oil of lead' which remains once the more volatile fractions of the lead acetate have been distilled off.[35]

He reasons that 'the Chymists will be apt to pretend, that these Oyls are but the volatiliz'd sulphur of the lead' (229.22-24), perhaps a reference to the Medieval theory that all metals consist of a combination of sulphur and mercury, and in the above example when the lead metal is decomposed, its sulphur content is liberated. He continues that they will 'perhaps argue it from what *Beguinus* relates' (229.25-26), that at the end of the distillation process one finds 'a *Caput Mortuum* [inert residue] extreamly black, and (as he speaks) *nullius momenti* [of no importance], as if the Body,

[34] Jean Beguin, (1550-1620) French-born medic and chemist, follower of Paracelsus, who published his *Tyrocinium Chymicum* [Chemistry for Beginners] in 1610.
[35] Carneades gives a fuller account of the distillation of lead acetate on 421.24-422.17.
See also Partington, *A History of Chemistry*, 2: 226.

or at least the chief part of the Metal it self were by the distillation carried over the Helme [head of the still]' (229.29 – 230.1-2).

Carneades does not agree with Beguin's rejection of the *Caput Mortuum* or inert residue left behind from the dry distillation of lead acetate, and goes on to state what he considers to be the composition of this residue. He says that his interlocutor knows as well as he himself does 'that *Saccharum Saturni* [lead acetate] is a kind of Magistery[36] made only by calcining [oxidising] of Lead *per se* [by itself]' (230.3-5), that is, prepared by heating lead in air, dissolving the oxidised lead 'in distill'd Vinager' (230.5-6), that is, in a solution of acetic acid, 'and crystalizing the solution' (230.6-7), when crystals of lead acetate are deposited from solution. Considerations of time prevent Carneades from relating how different he found the '*Caput Mortuum* [inert residue], so sleighted [slighted, or treated as of little importance] by *Beguinus*, to be from what he represents it' (230.9-11). Although he considers Beguin's account less plausible 'then [than] one or other of these three' (230.12-13).

The first possible explanation he lists is: 'that this Oyle did formerly concur [combine in action] to constitute the Spirit of Vinager' (230.13-15), from which he argues that 'what passes for a Chymical Principle may yet be further resoluble [resolvable] into distinct substances' (230.15-18). His second possible explanation is that 'some parts of the Spirit together with some parts of the Lead may constitute a Chymical Oyle' (230.18-20), *i.e*. may form a chemical compound, and 'which therefore though it pass for Homogeneous, may be a very compounded Body' (230.20-22). The third example

[36] A magistery is composed of the original elements of the body, freed from impurities.

involves not chemical reaction or chemical combination, but change to materials effected by transmutation. He surmises that 'at least by the action of the Distill'd Vinager [acetic acid] and the Saturnine Calx [lead oxide] one upon another, part of the Liquor may be so alter'd as to be transmuted from an Acid Spirit into an Oyle' (230.23-27). Although Carneades expresses a preference for the first two explanations in relation to the case in hand, yet he seems to consider the third one as being of most utility to him in this dialogue as a whole. He says that 'either of the two former conjectures' (230.28-29) are 'more pertinent to my present argument' (231.1-2), it is the third one, which his companion will recognise as useful 'to confirm some other passages of my discourse' (231.4-5).

Carneades reverts to what he was saying before mentioning '*Helmont's* Experiment' (231.7-8). He will add 'That Chymists must confess also that in the perfectly Dephlegm'd spirit of Wine [dehydrated alcohol]' (231.8-10) or other alcohol liquors 'that which they call the Sulphur of the Concrete, loses by the Fermentation, the Property Oyle' (231.11-14) 'of being unminglable with the Water' (231.16). What Carneades seems to be referring to here is that the alcohol distilled off wine is perfectly miscible with water, which is not as one would expect an oil to behave. And this despite the fact that oil is what 'the Chymists likewise take to be the true Sulphur of the Mixt' (231.14-15), that is, the inflammable portion of a chemical compound, yet alcohol, though not an oil, is highly inflammable.

Carneades then relates an account from van Helmont, in which he claims that 'all[37] of the purest Spirit of Wine [alcohol] may barely [simply] by the help of pure Salt of Tartar [potassium carbonate] (which is but the fixed Salt of Wine) be resolv'd or Transmuted into scarce [scarcely] half an ounce of Salt, and as much Elementary Water as amounts to the remaining part of the mention'd weight' (231.17-24). What van Helmont seems to be claiming is that some of the products of wine-making are connected through transmutation. Salt of tartar or potassium carbonate, produced from the tartar deposited during the fermentation and ageing process, may assist the alcohol produced by fermentation to be 'resolv'd or Transmuted' (231.21) into salt of tartar and water. This provides a mechanism for explaining how dissimilar products may arise from the production of wine.

Carneades remarks upon the fact that salt of tartar, or potassium carbonate, is produced by the thermal decomposition of potassium hydrogen tartrate or cream of tartar, the main constituent of tartar. He relates, he believes for the second time, that 'that Fixt and Alcalizate Salt [*i.e*. the salt of tartar], which is so unanimously agreed on to be the Saline Principle of incinerated Bodies' (231.26-29), as it is 'Alcalizate [alkaline], a Production of the Fire' (232.1-2), which is probably a reference to the fact that potassium carbonate or potash is also a constituent of wood-ash.

He notes, correctly, how the tartar has an acidic taste, as it is an acid salt of tartaric acid, then, when thermally decomposed, becomes potassium carbonate, with its alkaline taste. He states 'though the tast of Tartar' (232.2) 'seem [seems] to argue that it contains a Salt

[37] Corrected to 'a pound' in the *Errata*.

before it be burn'd, yet that Salt being very Acid is of a quite Differing Tast from the Lixivate [alkaline] Salt of Calcin'd Tartar [potassium carbonate]' (232.7).

Carneades accepts that the 'Chymists' (232.8) cannot be accused of obtaining 'all Salts they make, by reducing the Body they work on into Ashes with Violent Fires' (232.9-11), pointing out that materials such as Hartshorn,[38] Amber,[39] Blood, and divers [many] other Mixts yield a copious Salt' (232.11-13), that is, they yield a volatile fraction 'before they be burn'd to Ashes' (232.13-14). Yet the 'Volatile Salt' (232.14-15) is quite distinct 'from the Fixt Alcalizate [alkaline] Salt I speak of' (232.16-17), *i.e*. potassium carbonate or salt of tartar, 'as we shall see Anon [shortly]' (232.15-16), and 'which for ought [aught] I remember' (232.17-18) is produced only through incineration. He goes on to say that it is known 'to Chymists, that Quicksilver [mercury] may be Precipitated, without Addition, into a dry Powder, that remains so in Water' (232.20-23). What Carneades means here is unclear, perhaps it is a reference to the precipitation of the sparingly soluble, white, mercurous chloride or *calomel*, prepared by adding mercurous nitrate solution to excess of hot sodium chloride (common salt) solution.[40]

He says that 'some eminent *Spagyrists*,[41] and even *Raimund Lully*[42] himself teach [teaches] that meerly [simply] by the Fire Quicksilver [mercury] may in convenient

[38] The horn or antler of a hart, which was an important source of ammonia.
[39] A yellowish, translucent fossil resin.
[40] See Partington, *General and Inorganic Chemistry*, 396.
[41] Literally, those who take matter apart and put it together, a term attributed to Paracelsus. Alchemy was sometimes referred to as the Spagyric Art or Science.
[42] Ramon Lull/Llull (1232-1315/16) Catalan or Majorcean philosopher and Christian missionary to the Moors, to whom a number of works on alchemy have been attributed.

Vessels be reduc'd (at least in great part) into a thin Liquor like Water, and minglable with it' (232.23-29). What is meant here is unclear. Mercury, in common with most liquids becomes thinner, or less viscous, on heating, but at no point does it become miscible with water.

Following on from this statement, Carneades states that fire may alter the physical constitution of bodies, and what he seems to have in mind is that heat may cause a solid to melt, and for a liquid to become less viscous on heating, eventually becoming a gas (if it has not already undergone thermal decomposition). He says that by the 'bare [simple] Action of the Fire, 'tis possible, that the parts of a mixt Body should be so dispos'd after new and differing manners' (232.29 – 233.1-3), by which he may mean that the fire can alter the state of a body, melting solids, and evaporating liquids. A body, he states, 'may be sometimes of one consistence, sometimes of another' (233.4-5). This may be a reference to the change in viscosity as liquids are heated. In addition, a body 'may in one State be dispos'd to be mingl'd with Water, and in another not' (233.5-7). Perhaps he means that sometimes the liquid form of a material is water-soluble, though not the solid form.

He goes on to say that he 'could also shew [show] you' (233.8) that bodies that individually cannot yield any combustible product, but when brought together in the presence of fire, 'afford [yield] an inflamable Substance' (233.12-13). What Carneades has in mind here is unclear, but he may be thinking of an inflammable liquid such as alcohol, which in the bulk state, is difficult to ignite, yet when poured over a solid wooden surface, for example, the ascending alcoholic vapour is easily ignited.

By contrast, he adds that it would 'very much puzzle any ordinary Chymist, and perhaps any other, to separate an inflamable Principle or Ingredient' (233.15-18) from any inflammable body. In consequence of the above, Carneades offers two considerations to suggest that some materials produced through the agency of fire may not be the principles of compound bodies, but rather new materials in their own right. Firstly, he contends that the 'Principles of Chymists may receive their Denominations [designations] from Qualities' (233.19-21) which may be produced by the 'power of Art [technical skill]' (233.22), or perhaps that 'of the Fire to produce' (233.23), and since such qualities may occur in bodies which themselves 'differ so much in other Qualities from one Another' (233.25-26) 'that they need not be allow'd [acknowledged] to agree in that pure and simple Nature' (233.26-28) which principles, by definition, must have. From the foregoing, Carneades argues, it may 'justly be suspected that many Productions of the Fire that are shew'd [shown] us by Chymists, as the Principles of the Concrete [compound body] that afforded [provided] them, may be but a new kind of Mixts' (234.1-5).

Carneades next goes on to discuss the presence of the Paracelsian *Tria prima* of salt, sulphur and mercury, outside of the earth in the wider cosmos, and in constituting the four Aristotelian elements, saying that he will now 'Annex [add]' (234.6) 'to these arguments taken from the Nature of the thing, one of these which *Logicians* call *ad*

Hominem [to the man]'[43] (234.6-9) in which he disagrees with '*Paracelsus* Himself, and some that are so mistaken' (234.10-11), in believing that he could not be wrong, 'have ventur'd to teach' (234.12-13) that not only terrestrial bodies, 'but the Elements themselves, and all the other Parts of the Universe, are compos'd of Salt, Sulphur and Mercury' (234.14-17).

However, he affirms that 'the Learned *Sennertus*[44] and all the more wary [cautious] Chymists, have rejected that conceit [notion]' (234.17-19), and 'many of them confess [acknowledge] that the *Tria Prima* are each of them made up of the four Elements' (234.20-22). Still others of them 'make Earth and Water concur [combine in action] with Salt, Sulphur and Mercury, to the Constitution [making] of Mixt bodies' (234.23-25). From this he infers 'that one sort of these *Spagyrists*[45], notwithstanding the specious [apparently sound but fallacious] Titles they give to the productions of the Fire, do in effect grant what I contend [argue] for' (234.25-29). What Carneades seems to mean by this is not so much that earth and water plus the *tria prima* constitute all bodies, but that whatever elemental system is chosen as composing all materials it must include two fundamental elements or principles: earth and water.

Continuing in this vein, Carneades turns his attention to the other category of Spagyrists of whom he 'may well demand, to what Kind of Bodies the Phlegm [aqueous fraction] and dead Earth [*Caput Mortuum* or inert residue], to be met with in Chymical

[43] A personal attack in relation to the individual, rather than their argument.

[44] Daniel Sennert (1572-1637) German-born professor of medicine at Wittenburg. He accepted Paracelsus' theory of salt, sulphur and mercury as the three principles, but rejected other parts of the Paracelsian doctrine.

[45] Those who take matter apart and put it together.

Resolutions, are to be referr'd' (235.1-4), that is to say, if these materials are not constituted of the salt, sulphur, and mercury of the Paracelsians, of what then, do they consist? He goes on to stipulate that they must either agree with Paracelsus in saying against both 'their own Concessions [admissions]' (235.6) and experience, 'that these are also compos'd of the *Tria Prima*, whereof they cannot separate any one from either of them' (235.7-10), or, alternatively 'they must confess [acknowledge] that two of the Vastest Bodies here below, Earth, and Water, are neither of them compos'd of the *Tria Prima*' (235.10-13). One may conclude from this that these three principles 'are not the Universal, and Adequate Ingredients, neither of all Sublunary[46] Bodies, nor even of all mixt Bodies' (235.14-17).

That both principles and elements, by common consent are not pure substances, is now introduced into the discussion, with the idea that the decomposition products are named for the element or principle present to the highest proportion in them. He says he 'knows that the chief of these Chymists [probably Paracelsus] represent [presents], that though the Distinct Substances into which they divide mixt bodies by the Fire, are not pure and Homogeneous' (235.18-22), but also that 'since the four Elements into which the *Aristotelians* pretend to resolve the like bodies' (235.22-24) also by the fire, 'are not simple neither [either], as themselves acknowledge' (235.25-26), he argues that ''tis as allowable for the Chymists [Paracelsians] to call the one Principles, as for the Peripateticks [Aristotelians] to call the other Elements' (235.26-29). The reason for this is 'since in both cases the Imposition of the name is grounded only upon the

[46] A reference to the Aristotelian notion that all bodies below the orbit of the Moon consist of the four elements – earth, air, fire and water, but that the Moon and other celestial bodies consist of a fifth element or quintessence.

Predominancy of the Element whose name is ascrib'd to it' (235.29 – 236.1-3). He then says that he will not deny 'that this Argument of the Chymists [Paracelsians] is no ill [hostile] one against the *Aristotelians*' (236.4-6), perhaps accepting that the Paracelsians can tolerate the existence both of their own *Tria Prima* and the four elements of the Aristotelians as somehow subsisting in material substances.

Carneades now poses searchingly, and somewhat emotionally, a rhetorical question as to the benefits of these material systems to one who is seeking the true elements. He asks 'what Answer can it prove to me' (236.6-7) in his dispute 'Against the *Aristotelian* Elements, as the Chymical Principles' (236.7-9) and who cannot regard any material as 'a true Principle or Element' (236.10-11) but mixed or compounded of smaller units, 'which is not perfectly Homogeneous' (236.12-13) that is, not consisting of parts or elements all of the same kind, 'but is further Resoluble [resolvable] into any number of Distinct Substances how small soever' (236.13-15). He makes the point that the 'Chymists [Paracelsians] calling a body Salt, or Sulphur, or Mercury, upon pretence that the Principle of the same name is predominant in it' (236.15-18) is itself 'an Acknowledgement of what I contend [dispute keenly] for; namely that these productions of the Fire, are yet compounded bodies' (236.19-22).

He now queries the right of the Paracelsians to assert the existence of three distinct principles, whilst at the same time acknowledging that these are not to be separated in the pure state from compound materials. He argues that, as the Paracelsians grant that the substances produced through thermal degradation are not in themselves pure, yet 'it is affirm'd [stated as fact], but not prov'd [established] that the reputed Salt, or Sulphur, or Mercury, consists mainly of one body that deserves the name of a principle of the same Denomination [title]' (236.23-27). He now comes to the nub of the issue by asking how, in the materials under discussion, the Paracelsians or 'Chymists make it appear that there are any such primitive and simple bodies' (236.28-29) 'since 'tis upon the matter confess'd [acknowledged] by the Answer lately [a short time earlier] made, that these are not such?' (237.1-3).

Realising that the Paracelsians may attempt to appeal to reason as a means of justifying their doctrine of the *tria prima*, he asserts that this means that they cannot at the same time demonstrate experimentally their presence in compound bodies. He says that 'if they pretend [declare, claim] by Reason to evince [establish] what they affirm, what becomes of their confident boasts that the Chymists'[47] (237.4-6), who is called, 'after *Beguinus*',[48] (237.7) a *Philosophus* [philosopher] or *Opifex Sensatus* [a maker of thoughts]' (237.8), 'can convince our Eyes, by manifestly [unmistakably] shewing [showing] in any mixt body those simple substances he teaches them to be compos'd of?' (237.8-11).

What holds for the 'Chymists', Carneades argues, should hold for him as well. He argues that 'for the Chymists to have recourse in this case to other Proofs then [than] Experiments, as it is to wave [brandish] the grand Argument [proof] that has all this while been given out for a Demonstrative [serving as conclusive evidence] One'

[47] Corrected to 'Chymist' in the *Errata.*
[48] Jean Beguin (1550-1620) French-born medic and chemist, whose *Tyrocinium Chymicum* [Chemistry for Beginners] was published in 1610.

(237.12-16), then he equally is released 'From the obligation to prosecute [pursue] a Dispute wherein I am not engag'd to Examine any but Experimentall proofs' (237.17-20).

Carneades concedes that just because a named principle is not pure, it does not overturn the claim that such principles do subsist in materials. He says he knows that 'it may plausibly Enough be Represented [brought to view], in favour of the Chymists' (237.20-22) that in view of the fact that by far 'much the greater part of any thing they call Salt, or Sulphur, or Mercury, is really such; it would be very rigid [strict, harsh] to deny those Substances the names ascribed them' (237.22-27) on account of 'some sleight [slight] mixture of another Body' (237.27-28). He adds that 'since not only the Peripateticks [Aristotelians]' (237.28-29) regard specific materials as elementary, whilst at the same time acknowledging 'that Elements are not to be anywhere found pure, at least here below'[49] (238.2-3).

He acknowledges that chemical analysis may yield products close to those elements that are purported to be, and that this may be advanced in arguments. He says that 'since especially there is a manifest [obvious] Analogie and Resemblance [between] the bodies obtainable by Chymical Anatomies [chemical analysis] and the principles whose names are given them' (238.4-8), he acknowledges that he has 'consider'd that these things may be represented [made plain]' (238.8-9). He argues that although the Aristotelian understanding of the elements may be directed against them for allowing

[49] This is a reference to the Aristotelian doctrine of the quintessence or fifth element of which the celestial bodies were composed.

that terrestrial materials are never composed of pure elements, the same argument cannot be employed against him, as he holds that the elements must be pure substances. He says that he has already told his companion that ‘what is drawn from the Custome of the Peripateticks’ (238.10-11) ‘that though it may be employ’d against Them, Yet it is not available against me who allow [allows] nothing to be an Element that is not perfectly Homogeneous’ (238.12-16).

Carneades introduces another factor into the discussion in which he legitimately argues that only those pure elements clearly employed by nature in the synthesising of compound materials can reasonably be sought in the analysis of these bodies, and since no such elements are convincingly observed, either at the start or finish in the production and decomposition of compound materials, one can withhold judgement on their presence in those materials. So when ‘it is alledg’d [pleaded] that the Predominant Principle ought to give a name to the substance wherein it abounds’ (238.16-19), his retort is that this would ‘much more reasonably be said, if either we or the Chymists had seen Nature’ (238.20-21) take pure salt, sulphur or mercury ‘and compound of them every sort of Mixt Bodies’ (238.23-24).

If they rely on visual evidence in support of the presence of an element in a decomposition product of a plant, then they must also supply visual evidence that this particular element is indeed present in pure form in the plant prior to its decomposition. He states that ‘since ’tis to experience that they appeal, we must not take it for granted, that the Distill’d Oyle (for instance) of a plant is mainly compos’d of the pure principle call'd Sulphur, till they have given us an ocular proof [made evident to sight]' (238.24-29), that that kind of plant contains 'an Homogeneous Sulphur' (239.2).

Continuing with this line of reasoning, Carneades requests his interlocutor to recall that the point at issue is not whether compound materials yield decomposition products which in some way or another resemble putative principles, but rather that such compound materials can be broken down into a known number of truly elemental bodies. Carneades is dismissive of 'the specious [apparently sound but fallacious] argument, which is drawn from the Resemblance [between] the productions of the Fire' (239.3-5) and the named elements or principles, 'it will appear more plausible then [than] cogent [convincing]' (239.8-9) if he recalls 'the state of the controversie [dispute]; which is not, whether or no there be obtain'd from mixt Bodies' (239.9-12) decomposition products looking like, or agreeing with, 'some Qualities with Quicksilver [mercury] or brimstone [sulphur]' (239.13-14), or other like materials, but rather 'whether or no all Bodies confess'd [acknowledged] to be perfectly mixt were compos'd of, and are resoluble [resolvable] into a determinate number of primary unmixt Bodies' (239.16-19).

Carneades introduces a note of caution into the discussion by advising his companion that the experimental evidence they are considering lacks convincing proof. He is thereby reminding Eleutherius that the debate is concerned with the experimental as much as the rational, where clear proof of the identity of decomposition products is not readily achieved. He says that if his interlocutor keeps in mind the 'state of the question' (239.20) he will 'easily discerne that there is much of what should be Demonstrated, left unprov'd by those Chymical Experiments we are Examining' (239.21-24). Not wishing to 'repeat what I have already discover'd [shown] more at large [fully]' (239.25-26), he will now 'take notice [take heed] that it will not presently [immediately] follow' (239.26-27) that because a product obtained through the agency of fire 'has some affinity with some of the greater Masses' (239.28-29) of terrestrial matter, 'that therefore they are both of the same Nature, and deserve the same Name' (240.1-3).

He goes on to give examples of how 'Chymists' apply high standards of proof before accepting any particular material as a putative element or principle. He says that, although flame may be 'hot, dry and active' (240.6-7), because 'it wants [lacks] some other Qualities belonging to the nature of Elementary Fire' (240.7-9), the 'Chymists' (240.4) are not willing to accept it 'as a parcel of the Element of Fire' (240.5-6). He adds that neither will they 'let the Peripateticks [Aristotelians] call Ashes, or Quicklime [calcium oxide], Earth, notwithstanding the many likenesses between them' (240.9-12), as these substances, unlike earth, are not tasteless.

Carneades invites the question as to what 'all the Chymical Anatomies [chemical analysis] of Bodies do prove' (240.15-16), if not that they 'consist of the three Principles into which the fire resolves them' (240.17-19). His response is that 'their Dissections [chemical analyses] may be granted to prove, that some' (240.19-20), though not all, compound bodies 'are by the fire, when they are included [enclosed] in close [closed]

Vessels' (240.21-23), which is also 'often requisite [appropriate]' (240.24), 'dissoluble [resolvable] into several Substances differing in some Qualities, but principally in Consistence [degree of firmness]' (240.24-26).

He now lists the three categories of decomposition products obtained, then goes on to consider how they might correspond to the three Paracelsian principles. He says that 'out of most of them may be obtain'd a fixt [here: non-volatile] substance partly saline, and partly insipid [having little or no taste], an unctuous [oily] Liquor, and another Liquor or[50] more that without being unctuous, [oily] have a manifest [obvious] taste' (240.26-29 – 241.1-2). Carneades explains that his attitude towards the Paracelsian understanding of these products of analysis depends on how exactly they categorise them. He says that 'if Chymists will agree to call the dry and sapid [having taste or flavour] substance salt, the Unctuous [oily] liquor Sulphur, and the other Mercury' (241.2-5), he will accept this. He will object only if they tell him 'that Salt, Sulphur, and Mercury, are simple and primary bodies whereof each mixt body was actually compounded' (241.7-10), and truly present in it prior to thermal decomposition, regardless of what their 'other Arguments may do' (241.13-14), they must allow him to doubt whether 'their Experiments prove all this' (241.14-15).

Carneades justifies his exacting approach to considering which materials pass for elements, by arguing that if such materials do not meet his criterion of a uniform appearance, then he feels entitled to deny their elemental status. So that his companion may not believe that he deals 'so rigidly [strictly, harshly] with them, because I scruple

[50] The order of pages 241 and 242 is reversed in the 1661 edition.

[hesitate]' (241.22-23) to accept products of thermal decomposition 'for such as the Chymists [Paracelsians] would have them pass for, upon the account of their having some affinity with them' (241.24-27), he requests that Eleutherius take note of the fact 'that in regard [aspect, appearance] an Element or Principle ought to be perfectly Similar and Homogeneous' (241.28-29 – 242.1). Therefore he believes that there is 'no just cause' (242.1) why he should accept that particular material as 'this or that Element or Principle, because it has a resemblance to it in some obvious Quality' (242.3-5), rather than reject it because of 'divers [many] other Qualities, wherein the propos'd Bodies are unalike' (242.7-8). Moreover he asks his companion to 'consider what sleight [slight, flimsy] and easily producible qualities they are that suffice' (242.9-10), he reiterates, 'to Denominate [name] a Chymical Principle or an Element' (242.12-13), that is to say, how readily the Paracelsians accord elemental status to a thermal decomposition product. He hopes that Eleutherius will not consider his 'wariness [caution] to be destitute [devoid of] either of Example, or else of Reason' (242.14-15).

He goes on to remark that 'the Chymists [Paracelsians] will not allow [concede] the *Aristotelians* that the Salt in Ashes ought to be called Earth' (242.16-18), contrary to what one would expect, as the 'Saline and Terrestrial part symbolize in weight, in dryness, in fixness [non-volatility] and fusibility [capacity to be melted]' (242.18-20), that is, they have the properties characteristic of earth. Yet, 'because the one is sapid [having taste or flavour] and dissoluble [soluble] in Water' (242.20-22), meaning, these properties cause this component of the ashes to be considered as saline, 'and the other not' (242.22), that is to say, the terrestrial component does not possess these properties.

In addition, Carneades continues, ‘we see that sapidness [having taste or flavour] and volatility are wont [usual] to denominate [name] the Chymists Mercury or Spirit’ (242.22-25). Yet he asks his companion to consider how these properties can be reconciled with the composition and behaviour of many materials. ‘How many Bodies’ (242.25) ‘may agree in these Qualities which may yet be of very different natures, and disagree in qualities either more numerous, or more considerable, or both’ (242.26-29). He reinforces his argument by listing a set of liquids which do not easily fit into the category to which the Paracelsians would have them assigned. He says that ‘not only Spirit of Nitre [nitric acid], Aqua Fortis [nitric acid], Spirit of Salt [hydrochloric acid], Spirit of Oyle of Vitriol [sulphuric acid], Spirit of Allome [alum], Spirit of Vinager [acetic acid]’ (243.1-4), but also ‘all the Acetous Spirits of Woods freed from their Vinager’ (243.5-7), by which he may mean the remainder of the liquor left behind after its acetic acid has been distilled off.

All of the above, Carneades maintains, ‘and many others must belong to the Chymists Mercury’ (243.7-9), as all of these liquors are volatile. Yet, because of their other qualities ‘it appear [appears] not why some of them should more be comprehended’ (243.9-11), by which he probably means by the Paracelsians ‘under one denomination [name] then [than] the Chymists Sulphur, or Oyle should likewise be’ (243.11-13). This probably means that Carneades believes they should not be assigned to only one of the Paracelsian three principles, the reason being that ‘their Distil’d Oyles’ (243.13-14), that is, the liquid fraction which can be distilled off from them, ‘are also Fluid, Volatile, and Tastable, as well as their Mercury’ (243.14-16).

Continuing with this theme, Carneades says that is not ‘Necessary, that their Sulphur should be Unctuous [oily] or Dissoluble [soluble] in Water, since they generally referr Spirit of Wine [alcohol] to Sulphurs’ (243.16-19), meaning that alcohol, being inflammable, would be considered as a sulphur by the Paracelsians. And this ‘although that Spirit be not Unctuous [oily] and will freely mingle with Water’ (243.20-21). It follows from this, he says, ‘that bare [simple] Inflamability must constitute the Essence of the Chymists Sulphur’ (243.22-24), ‘as uninflamablenesse joyned with any taste is enough to intitle a Distill’d Liquor to be their Mercury’ (243.24-26).

He goes on to remark to his interlocutor ‘that Spirit of Nitre [nitric acid] and Spirit of Hartshorne [ammonia] being pour’d together will boile and hisse and tosse up one another into the air’ (243.28-29 – 244.1-2). What Carneades is here describing is the chemical reaction whereby ammonia is neutralised with nitric acid to form ammonium nitrate and water, which reaction would be accompanied by the release of heat. This latter, Carneades interprets as ‘signes of great Antipathy in the Natures of Bodies (as indeed these Spirits differ much both in Taste, Smell, and Operations [effects or results produced])’ (244.3-6), which is true, as both nitric acid and ammonia have strong, though distinct odours, the one being an acid, the other an alkali.

Carneades reminds Eleutherius of telling him elsewhere his having 'made two sorts of Oyle out of the same mans blood, that would not mingle with one another' (244.7-10). He advises his companion that 'since I might tell You Divers [various] Examples I have met with, of the Contrariety of Bodies' (244.10-12) which the 'Chymists' (244.13) hold 'must be huddl'd up together under one Denomination [name]' (244.13-15). He invites Eleutherius to decide 'whether such a multitude of Substances as may agree in these sleight [slight] Qualities, and yet Disagree in Others more Considerable' (244.15-19) deserve more the 'Name of a Principle (which ought to be pure and homogeneous,) than to have appellations [names] given them' (244.22-23) which may cause them to differ greatly in both names and qualities from the natural materials for which they are called.

He continues to expound his reservations of the Paracelsians' rationale by which they assign different substances to one of their three principles of salt, sulphur and mercury. He justifies this approach towards his adversaries by saying that 'hence also, by the bye [in passing]' (244.26), by explaining that the 'Chymists way of Argumentation' (244.28-29) is inadequate 'to shew [show] us that such a Liquor is (for Example) purely saline' (244.29 – 245.1-2) they do demonstrate that, due to its strong taste, 'and all Tast proceeds from salt' (245.5) that 'salt is much the predominant Principle' (245.2-3) in this particular liquor. However, materials reckoned by the Paracelsians as mercuries, due to their volatility, may also be strongly tasting. He states that 'those Spirits, such as spirit of Tartar,[51] spirit of Harts-Horn [ammonia], and the like' (245.6-7), which are called the mercuries of their parent bodies, 'have manifestly [obviously] a strong and

[51] The liquid obtained by the dry distillation of tartar – itself deposited during the production of wine – and containing pyrotartaric acid and other substances.

piercing tast' (245.9-10). This is true also, as already noted by Carneades, of the 'spirit of Box &c. even after the acid Liquor that concurr'd [combined] to compose it has been separated from it' (245.12-14).[52]

Carneades develops his discussion of the presence of a mercurial principle in materials by making the point that 'if sapidness [having taste or flavour] belong [belongs] not to the spirit or Mercurial Principle of Vegitables and Animals, I scarce know how it would be discriminated [differentiated] from their phlegm [aqueous fraction], since by the absence of Inflamability it must be distinguish'd from their sulphur' (245.15-20). What he seems to mean here is that, if taste or flavour is to be attributed to the saline principle, and inflammability to the sulphurous one, then uninflammable, taste-bearing liquors must have their tastefulness attributed to their saline component, leaving only their tasteless liquid fraction as comprising their mercurial principle. The trouble is, such a bland liquid would be indistinguishable from their aqueous fraction.

The foregoing provides Carneades with another example 'to prove how unaccurate the Chymical Doctrine is in our present Case' (245.21-23), this time by considering the strongly scented (and tasting) oily, and volatile, fractions derived from some plants and animals which would most likely distil over after their more insipid aqueous fractions. He avers that not only 'the spirits [volatile fractions] of Vegitables and Animals, but their Oyles are very strongly tasted' (245.24-26). By way of verification he suggests

[52] This destructive distillation of wood results in the condensing of a range of products, including an acidic fraction (acetic acid and some tarry compounds) as well as methanol and acetone. Even with the acidic fraction removed, the other distillation products would, collectively, have a strong, rather pungent, odour.

that one might 'wet his tongue with Chymical Oyle of Cinnamon, or of Cloves' (245.26-28), which would have intense though not unpleasant flavours. He adds to these 'even [oil] of Turpentine' (245.28), which would have a strong, woody taste, as one 'may quickly find, to his smart [sharp physical pain]' (245.28-29).

Carneades takes the strong taste and odour of plant-derived oils as further evidence that such materials, no matter how pure, retain their taste and odour-bearing qualities, yet their oiliness also remains, thereby disqualifying them from classification as saline bodies. He says that although he 'never try'd any Chymical Oyles whose tast was not very manifest [obvious] and strong' (246.1-2), 'a skilful and inquisitive person' (246.3) dedicated to 'by elaborate operations to depurate [purify] Chymical Oyles, and reduce them to an Elementary simplicity' (246.4-6), 'Informes us, that he never was able to make them at all Tastless' (246.6-8). The fact that carefully purified oils still retain their obvious odours and tastes, allows Carneades to infer 'that the proof Chymists [Paracelsians] confidently give us of a bodies being saline' (246.9-10) 'does not clearly Evince [establish] so much as the presence of the saline Principle' (246.12-14) in the oils, thereby clearly demonstrating 'the Predominancy' (246.11-12) of this principle in such liquors as impossible.

Not wishing to overstress his point, but wishing to remind his companion of the 'incompetency [inadequacy] of this sort of Chemical argument' (246.23-24), by which he means the practice whereby 'most Chymists deduce Odours from Sulphur, and from them argue the Predominancy of that Principle in an Odorous body' (246.18-21), though not before listing some materials of a saline nature: 'the Volatile salts of Harts-horn [ammonia], Amber [here: succinic acid], Blood &c. are exceeding strongly scented' (246.15-17), as a means of illustrating his point. By pointing up the incontrovertible fact that saline materials may also share the characteristics of another principle, such as sulphur, Carneades offers a direct contradiction to the Paracelsian doctrine. Now wishing to proceed with the discussion he realises that he has detained his companion 'too long in those generals [general points] that appertain [belong to] to my fourth consideration' (246.25-26), he is anxious 'to proceed to the particulars themselves, to which I thought fit they should be previous [leading the way]' (246.27-29).

These general points 'being thus premis'd [stated]' (247.2), by Carneades, he draws attention to the possibility that if one objectively notes in the various materials, when analysed chemically, the putative presence of the Paracelsian *tria prima* of salt, sulphur and mercury in them, it is unlikely that one would find that all materials consist of a single salt, a single sulphur and a single mercury. He says that an 'attentive and unprepossess'd [unbiased] observer' (247.2-4) would be unlikely to note 'in each sort of Bodies which the Chymists are wont [accustomed] to call the salts or sulphurs or Mercuries of the Concretes that yield Them' (247.5-8), as though each one had both a simplicity and identity. Yet if all salts were elementary they 'would as little differ as do the Drops of pure and simple Water' (247.11-12).

Carneades now goes on to list some examples which illustrate the differences in behaviour and properties that occur among salts. He says 'that both Chymists and

Physitians [physicists] ascribe to the fixt salts [here: oxides or soluble inorganic combustion products] of calcin'd [burned] Bodies the vertues [powers] of their concretes [here: parent bodies]' (247.13-15) and to these 'Consequently very differing Operations [actions, influences]' (247.15-16). He quotes the '*Alkali* of Wormwood'[53] much recommended in distempers [disorders] of the stomach; that of Eyebright[54] for those that have a weak sight' (247.17-20). The alkali of '*Guaiacum*'[55] (247.20) is, he says, 'much commended in Venereal Disease' (247.22-23), and is also 'believed to have a peculiar [remarkable] purgative vertue [power]' (247.24-25).

Carneades admits that he believed that he had originally thought that 'these *Alkalizate* [alkaline] salts are for the most part, very neer of kin [related in qualities]' (247.27-28), retaining very few of the properties of the 'Concretes [compound bodies] whence they were separated' (248.1-2). 'Yet being minded [intending]' (248.2) to seek out exceptions to this 'General Observation' (248.4-5), he went to the 'Glasse-house' (248.5) and observed there 'that sometimes the Metal (as the Workmen call it) or Masse of colliquated [fused] Ingredients, which by Blowing they fashion into Vessels or divers [many] shapes, did sometimes prove of a very differing colour, and a somewhat differing Texture, from what was usuall' (248.5-12). Enquiring whether such 'Accidents [here: properties]' (248.13) might be due to the 'peculiar [distinctive] Nature

[53] The plant *Artemisia Absinthium*, proverbial for its bitter taste, and which yields a bitter oil. The leaves and top are used as a tonic and vermifuge, and for making vermouth and absinthe. They have been used to protect clothes and bedding from moths and fleas. What Carneades seems to be referring to is the salt of wormwood, which is potash or potassium carbonate, in this instance obtained from the ashes of wormwood.

[54] The popular name of the plant *Euphrasia officinalis*, formerly in repute as a remedy for weak eyes.

[55] *Guaiacum officinale* and *Guaiacum sanctum*, used in medicine.

of the fixt salt employed to bring the sand to fusion'[56] (248.14-16), the 'knowingst Workmen imputed [attributed] these Mis-adventures to the Ashes, of[57] some certain kind of Wood'[58] (248.16-19). They found that the 'ignobler kind of Glass' (248.20) just mentioned, frequently resulted from the kinds of ashes which 'therefore they scruple [hesitate] to make use of' (248.23), if they spotted them in time.

His next example is of 'an Industrious Man' (248.25), with whom he is aquainted, who bought 'a vast quantity of Tobacco stalks to make a fixt Salt with' (248.26-28). Carneades, wondering how this plant 'which so much abounds in volatile salt, would afford a peculiar [distinctive] kind of *Alcali*' (248.29 – 249.1-2), found to his satisfaction that in the *Lixivium* [separated alkaline product] of it' (249.3-4), unusually, he did not have to evaporate off all of the mother liquor 'that there might be obtain'd a Saline Calx [a soluble, incombustible product, having a taste] consisting like lime quench'd in the Air' (249.5-7). He seems to mean by this resembling some quicklime, or calcium oxide, following its slaking or hydration by the addition of water, and which would be comprised 'of a heap of little Corpuscles [here: minute particles] of unregarded [unesteemed] shapes' (249.7-9). Instead, what he found was that the 'fixt salt [saline product] shot into figur'd Crystal [took on a crystalline form], almost as Nitre [potassium nitrate or saltpetre] or *Sal-armoniack* [ammonium chloride] and other uncalcin'd salts are wont [accustomed] to do' (249.9-12). What may have happened

[56] Glass is typically prepared from white sand, sodium or potassium carbonate, and lime.
[57] Changed to 'Ashes off' in the *Errata*.
[58] What Carneades seems to be referring to is the fact that different sources were used to produce the ash from which sodium or potassium carbonate was obtained. Sodium carbonate was prepared by burning certain sea-shore plants, whereas wood-ash contains potassium carbonate.
See: Partington, *General and Inorganic Chemistry*, 306.

here is that the burnt tobacco stalks were unusually rich in potash or potassium carbonate which crystallised out as the translucent granular form rather than the white powder which Carneades had anticipated.[59]

He next observes 'in the fixt Salt of Urine [ammonium chloride] brought by depuration [purification] to be very white, a taste not so unlike that of common salt'[60] (249.13-15), which he found 'very differing from the wonted [customary] caustic Lixiviate [alkaline] taste of other salts made by Incineration' (249.16-18). Conceding that because the examples he has 'alledg'd [cited, quoted] of the Differences of *Alcalizate* [alkaline] salts are but [only] few' (249.19-20) consequently he considers 'that most Chymists and many Physitians [physicists] do, inconsiderately [unadvisedly] enough and without Warrant [conclusive proof] from Experience' (249.21-24) attribute the 'Vertues [here: properties] of the Concretes [compound bodies]' (249.24-25) undergoing 'Calcination' (249.25), or thermal degradation, to the 'salts [soluble, inorganic products] obtain'd by it' (249.26).

By contrast, Carneades wishes to demonstrate the 'Disparity [dissimilarity] of salts' (249.27), and begins by mentioning 'the apparent Difference [between] the Vegetable fixt salts and the Animal Volatile ones' (249.28-29 – 250.1). The examples he gives are 'salt of Tartar [potassium carbonate] and salt of Harts-horn [ammonium carbonate]' (250.2-3). The former, he says, is 'so fixt [inert]' (250.4) as to bear a high temperature fire 'and stand in fusion like a metal' (250.5-6), by which he seems to mean that it will

[59] See: *The Oxford Dictionary of Chemistry*, 432.
[60] Ammonium chloride has a salty, astringent taste.

withstand attempts at melting it as well as a metal, but that when eventually melted (which occurs at 891^{o}C) the glowing molten mass of potassium carbonate resembles that of a metal. This would be the case as metals with a similar melting point to it, such as silver (melting point 962^{o}C) would also glow when molten.

The latter salt, he maintains, apart from being different in taste and very different in odour, 'is so far from being fixt [non-volatile] that it will fly away in a gentle heat as easily as spirit of Wine [alcohol] it self' (250.8-10). Carneades seems to be referring to the fact that ammonium carbonate, or sal volatile, sublimes, that is, passes from a solid to a vapour without ever becoming liquid. Alcohol is quite volatile and it too, readily, evaporates into the vapour state upon heating.

Carneades next notes the considerable difference among volatile salts, citing 'the distinct Properties of (for Instance) salt of Amber[61], salt of Urine [ammonia], salt of Mans Skull [tricalcium phosphate], (so much extoll'd against the falling Sicknesse [epilepsy])' (250.14-17). He observes that there is a distinction in crystal habit between the different salts. There is sometimes a discernable difference among these, he says, 'in their Figures' (250.21-22). He notes that 'salt of Harts-horn [probably: ammonium chloride]' (250.22) he has observed adhering 'to the Receiver in the forme almost of a *Parallelipipedon*'[62] (250.23-24) in the 'Volatile salt of humane blood [probably: ammonium chloride] (long digested before distillation, with spirit of Wine [alcohol])'

[61] Succinic acid, a product of the dry distillation of amber.
[62] A parallelipipedon is a prism whose base is a parallelogram.

(250.25-27), he 'can shew [show] you store [abundance] of graines [crystals] of that Figure which *Geometricians* call a *Rhombus*'[63] (250.27-29).

Carneades seems to understand that the crystals of ammonium chloride can adopt various crystal habits, when he remarks that he 'dare not undertake [accept] that the Figures of these or other Saline Crystals' (250.29 – 251.1-2), 'will be alwaies the same' (251.3), irrespective of the temperature 'employ'd to force them up' (251.4-5), perhaps a reference to the heat applied to ammonium chloride in order to cause it to evaporate or sublime, then deposit in crystalline form on a cool surface. He continues that not only is the applied heat important, but also 'how hastily soever they may have been made to convene [come together] in the spirits or liquors, in the lower part of which I have usually observ'd them after a while to shoot [stream out]' (251.5-9).

He goes on to contrast the medicinal qualities of what seem to be the inert, saline products of the thermal decomposition of various plants compared with those of the more volatile – by which he may mean here combustible – potassium nitrate or saltpetre, formed when heaps of nitrogenous organic material are left to decay in the open air. Carneades reminds his interlocutor that he 'seldom found any Difference as to Medicinal Vertues [here: properties] in the fixt [inert] Salts [probably: potassium carbonate] of Divers [several] Vegetables' (251.10-12). As a result of which he has 'suspected that most of these volatile Salts [probably: potassium nitrate] having so great a Resemblance in smell, in tast, and fugitiveness [volatility]' (251.13-16) have little or

[63] A plane rectilinear figure having four sides and equal opposite angles, *spec.* one having no right angles, as contrasted with a square.

no difference in ‘their Medicinal properties’ (251.17). He cites their general uniformity of action in ‘divers [many]’ (251.19) of them, being ‘somewhat Diaphoretick [promoting or inducing perspiration] and very Deopilative [tending to remove obstructions]’ (251.20-23).

Yet Carneades recalls van Helmont as saying that there is ‘this Difference [between] the saline spirit of Urine and that of Mans blood’ (251.26-28), by which he seems to be referring to ammonium chloride prepared from different sources, remarking that only the latter of these will cure epilepsy. He mentions the efficacy ‘of the Salt of Common Amber’[64] (252.2-3) in curing epilepsy in children, and which he may ‘have an Occasion [opportunity] to Entertain [discourse to] You’ (252.6).

Carneades contrasts the difference between the efforts required to obtain the saline products prepared by incineration and those of a volatile nature. This serves both as further evidence of their mutual differences and of their non-elemental nature. So when he considers that the production of ‘these Volatile Salts (especially that of Urine)’ (252.8-9), by which he probably means ammonium chloride, does not require the same high temperatures to produce as ‘those Salts that must be made by Incineration’ (252.11-12). Carneades seems to have in mind potassium carbonate. This causes him to tend towards the belief that such salts ‘may differ from one another, and consequently recede [depart] from an Elementary Simplicity’ (252.14-16).

[64] Succinic acid, produced by the dry distillation of amber.

Carneades continues with his exposition of the distinctions between the various salts by citing some evidence from Boyle himself, obviously still present as a silent note-taker. He avers that if he could ‘here shew [show] You what Mr. *Boyle* has Observ’d, touching the Various Chymical Distinctions of Salts’ (252.16-19), one would see that ‘not only that Chymists do give themselves a strange Liberty to call Concretes [compound materials] Salts’ (252.20-22), which in their understanding are to be considered ‘as very [truly] Compounded Bodies’ (252.23-24) but that ‘among those very [actual] Salts, that seem Elementary’ (252.24-26) as they result from the ‘Anatomy [chemical analysis] of the Bodies that yield them, there is not only a visible Disparity’ (252.27-29), but ‘a manifest [obvious] Antipathy or Contrariety [repugnancy]’ (253.1-2). This, he continues, is ‘evident in the Ebullition [boiling] and hissing that is wont [customary] to ensue, when the Acid Spirit of Vitrioll [sulphuric acid], for Instance, is pour’d upon pot ashes [potash or potassium carbonate] or Salt of Tartar [also: potassium carbonate]’ (253.2-6).

Carneades refers to Boyle’s work on ‘some Preparations of Urine’ (253.10-11) in which a given body ‘may have two Salts of a contrary Nature, as he exemplifies in the Spirit [nitric acid] and *Alkali* of Nitre [potassium nitrate]’ (253.12-15), and from which ‘there may without addition be Obtain’d three differing and Visible Salts’ (253.16-17). He explains that ‘He Relates, that he observ’d in Urine, not only a Volatile and Crystalline Salt [probably sal ammoniac or ammonium chloride], and a fixt [non-volatile] Salt [possibly urea, the major saline constituent of urine], but likewise a kind of *Sal Armoniack* [ammonium chloride]’ (253.18-21).

This latter product perplexes Carneades, as he does not quite know what to make of it. He does observe that it was 'such a Salt as would sublime in the form of a salt, and therefore was not fixt [non-volatile]' (253.21-23), and it puzzles him that it 'yet was far from being so fugitive as the Volatile salt' (253.23-25), meaning, less volatile than ammonium chloride. Yet from this product 'it seem'd also otherwise to differ' (253.25-26). He has suspected that it 'may be a *Sal Armoniack* [ammonium chloride]' (257.27) 'as Compounded of the Volatile salt of Urine, and the fixt [non-volatile] of the same Liquor' (253.28-29 – 254.1). This latter he has noted 'is not unlike sea-salt' (254.2), by which he probably (and rightly) means the chloride radical of the sodium chloride present in sea-salt. However, he cautions that this analysis or explanation 'argues a manifest [obvious] Difference [between] the salts' (254.3-4) believing that 'such a Volatile salt [here: ammonia] is not wont [accustomed] to Unite thus with an ordinary *Alcali*, but to fly away from it in the Heat' (254.4-7).

Carneades goes on to recall how in order to give some friends 'an Ocular [visual] proof of the difference [between] the fixt [non-volatile] and Volatile salt (of the same Concrete [compound material]) Wood, I devis'd the following Experiment' (254.9-12). He 'took common Venetian sublimate [corrosive sublimate or mercuric chloride]' (254.12-13) and made a saturated solution of it in 'fair [clean] Water' (254.15). He then 'took Wood Ashes' (254.15), and using warm water, washed out 'their salt; and filtrating [filtering] the Water (254.17-18) as soon as he 'found the *Lixivium* [alkaline solution] sufficiently sharp upon the tongue' (254.18-19), that is, when it was sufficiently concentrated, he 'reserv'd it for use' (254.20).

He carried out a separate experiment on each of two portions of the solution of Venetian or mercuric sublimate, *i.e*. mercuric chloride. 'on part of this solution of sublimate dropping a little of this Dissolv'd Fixt salt of Wood [potassium carbonate], the Liquors presently [immediately] turn'd of an Orange Colour' (254.20-24). What seems to have happened here is that Carneades in adding some of the strongly alkaline potassium carbonate solution to a hot solution of mercuric chloride, it caused the formation of mercuric oxide, in the form of an orange solution.[65] He found that 'upon the other part of the clear solution of sublimate putting some of the Volatile salt of Wood [ammonia solution] (which abounds in the spirit of soot [ammonia]) the Liquor immediately turn'd white, almost like Milke, and after a while let fall a white sediment' (254.24-29 – 255.1). What seems to have occurred in this case is that Carneades added some ammonia solution to a solution of potassium carbonate, forming a white precipitate of aminomercurial chloride.[66]

Carneades concludes his description of these experiments by saying that 'the other Liquor' (255.2), that is, the one formed in the first part of the experiment, deposited 'a Yellow one' (255.2), meaning a yellow precipitate. What he seems to be referring to is that the orange precipitate which formed initially, cooled to a yellow one, possibly due to the yellow particles of mercuric oxide being finer than the orange ones. Carneades

[65] See: Partington, *General and Inorganic Chemistry*, 398.
[66] See: Partington, *General and Inorganic Chemistry*, 402.

wishes to bring this part of the discussion, on the 'difference of Salts' (255.5-6) to a close, and reminds his interlocutor of what he said earlier 'concerning the simple spirit of Box, and such like Woods' (255.8-10), by which he probably means the distillate obtained by the destructive distillation of wood, and consisting mainly of acetic acid, acetone and methanol. This spirit, he maintains, differs 'much from the other salts hitherto mention'd' (255.10-11), which is the case, as it consists of a mixture of liquid organic compounds. However, Carneades claims that this distillate 'would belong to the saline Principle, if Chymists did truly teach that all Tasts proceed from it' (255.12-14). He continues that he 'might also annex [add], what I noted to you out of *Helmont* concerning Bodies' (255.15-16), which consisting principally of 'Chymical Oyles, do yet appear but [only] Volatile salts' (255.18-19). He admits that 'to insist [stand on]' (255.19) these items would be to engage in repetition, and decides to proceed instead.

He begins this part of the discussion by remarking that 'This disparity is also highly eminent [noteworthy] in the separated sulphurs or Chymical Oyles of things' (255.22-24). He argues that 'they contain so much of the scent, and tast, and vertues [properties]' (255.24-25), of the materials from which they are derived, 'that they seem to be but [only] the Material *Crasis* [blending] (if I may so speak) of their Concretes [compound bodies]' (255.27-29).

He develops his argument by saying that 'the Oyles of Cinnamon, Cloves, Nutmegs and other spices, seem to be but [merely] the United Aromatick parts that did ennoble [elevate] those Bodies' (255.29 – 256.1-4). He observes that some of these oils, *viz*.

'Oyl of Cinnamon, and oyle of Cloves' (256.4-5) and of several, 'will sink to the Bottom of Water' (256.7-8) as these oils are denser than water, 'whereas those of Nutmegs and divers [several] other Vegetables will swim upon it' (256.8-10). He continues that 'The Oyle (abusively [improperly] call'd spirit) of Roses swims at the Top of the Water in the forme of a white butter' (256.10-13). The whitening of the oil is probably due to the partial crystallisation of some of its constituents when the oil is placed in contact with cold water, a property Carneades had not observed in 'any other Oyle drawn in any Limbeck [alembic, or distillation apparatus]' (256.14-15). He goes on to note that there is a method which is 'not here to be declar'd [described]' (256.16), by which he has seen it distil over 'in the forme of other Aromatick [yielding aroma] Oyles' (256.17-18).

What Carneades is so tight-lipped about may be the process of steam distillation, by which a liquid, immiscible in water, such as rose-oil, is distilled in a current of steam, and which would result in a purified oil as distillate. This would seem to have been an unusual practice, as Carneades states that the product provided a source of 'Delight and Wonder' (256.19) to 'those that beheld it' (256.19-20).

He goes on to speak of 'Oyle of Anniseeds' (256.20) which he drew 'both with, and without Fermentation' (256.21-22). The process of fermentation was, perhaps, employed by Carneades as a means of liberating the oil from the other constituents present in the plant. He observed that, on cooling, the oil thickened 'into the Consistence and Appearance of white Butter' (256.24-25). The fact that 'with the least heat' (256.25-26) it 'resum'd its Former Liquidness' (256.26), may again mean that the cool temperature caused partial crystallisation of some of the constituents of the oil, which regained its former appearance on heating.

Carneades then describes how on distilling 'Oyle of Olive' (256.27) he has sometimes 'seen a spontaneous Coagulation in the Receiver' (256.29 – 257.1), adding that he still has some of this 'Congeal'd [coagulated]' (257.2) product, 'which is of such a strangely penetrating scent, as if 'twould Perforate the Noses that approach it' (257.2-4). What Carneades seems to be describing is the distillation of olive oil during which some decomposition occurred, and that one of the decomposition products was a small amount of acrolein, which has a toxic, acrid, and intensely irritating vapour to eyes and nose.[67] He relates that 'The like pungent Odour I also observ'd in the Distill'd Liquor of common sope, which forc'd over from *Minium*[68], lately afforded an oyle of a most admirable Penetrancy' (257.5-9), which latter property indicates that some acrolein was liberated during the decomposition of soap, when heated in the presence of an effective oxidising agent – *Minium*.

He reinforces this line of reasoning by upbraiding the one who 'must be a great stranger, both to the Writings and preparations of Chymists' (257.9-11) who does not see 'a considerable and obvious Difference' (257.13-14) between the oils they distil 'from Vegetables and Animals' (257.12-13). Carneades refers again to the difference in density between oils obtained from the same source. This Eleutherius may 'think of kin

[67] See also: David W.A. Sharp, ed. *The Penguin Dictionary of Chemistry*, 3rd ed. (London: Penguin Books, 1983), 166.
[68] Red lead or dilead (II) lead (IV) oxide.

[relation] to a Paradox' (257.16), that is, is contrary to received opinion or belief, 'that divers [many] times out of the same Animal or Vegetable, there may be extracted Oyles of Natures obviously differing' (257.16-19), that is, those oils whose densities are lower or higher than that of water. Such oils he has seen to 'float on, and subside [settle] under the spirit [here: volatile fraction] of *Guajacum*[69], and that of divers [many] other Vegetables' (257.22-25) by effective distillation.

Neither will Carneades dwell on the already mentioned yielding of the 'divers [many] and unminglable [immiscible] oyles' (257.27-29) obtained from human blood which has been 'long fermented and Digested with spirit of Wine [alcohol]' (257.29 – 258.1). He explains that these oils 'may seem chiefly to differ in Consistence [degree of firmness] and Weight [here: density], being all of them high colour'd and adust [burnt or scorched]' (258.2-5). Still thinking of the difference in oils obtained from the same body, he says that he will describe an experiment whereby one can discern 'this Difference of the oyles of the same Vegetable, *ad Oculum* [visually]' (258.6-8).

He relates that he 'took a pound of Annisseeds, and having grosly [coarsely] beaten them, caused them to be put into a very large glass Retort almost filled with fair [clear] Water' (258.9-13). This he placed in 'a sand Furnace' (258.13-14), which would avoid overheating the apparatus and its contents. A 'very Gentle heat' (258.14-15) was applied on the first day, and for much of the second, until the water had distilled over 'and had brought over with it at least most of the Volatile and Aromatick [yielding aroma] Oyle of the seeds' (258.18-20). He then increased the heat applied, changed the

[69] Probably the resin of the *Guaiacum officinale* or the *Guaiacum sanctum* tree.

receiver, and 'obtain'd besides an Empyreumatical [tasting or smelling of burnt organic matter] Spirit, a quantity of adust [burnt or scorched] oyle' (258.22-24), of which 'a little floated upon the Spirit [volatile organic fraction], and the rest was more heavy [here: denser], and not easily separable from it' (258.24-26).

He recounts that the oils obtained from the higher temperature distillation, which would have discoloured and have undergone some thermal decomposition, 'were very dark, and smell'd (as Chymists speak) so strongly of the Fire' (258.27-29), so much so that one could not tell 'from what Vegetables they had been forc'd' (259.1-2). By contrast, the first fraction whose vapour had been carried over with steam, and which had not undergone either discoloration or decomposition, *i.e*. 'the other *Aromatick* [yielding aroma] Oyle was enrich'd with the genuine smell and tast of the Concrete [compound material]' (259.2-4). This fraction had a lower freezing point than the second, as he noted it 'spontaneously coagulating itself into white butter[70] did manifest self[71] to be the true Oyle of Annisseeds' (259.4-7). It was this very difference between the distillation products of aniseeds which caused Carneades to choose this particular product for his experiment.

Almost as an afterthought Carneades remembers that he has forgotten to take notice of 'another sort of Bodies, which though not obtain'd from Concretes [compound materials] by Distillation, many Chymists are wont [accustomed] to call their Sulphur' (259.14-17). Their reason is twofold: colour and solubility. These materials are usually 'high colour'd (whence they are also, and that more properly, called Tinctures [coloured

[70] Thereby showing that it was a partially crystalline material.
[71] Corrected to 'it self' in the *Errata*.

principles]) as dissolv'd Sulphurs are wont [accustomed] to be' (259.18-21). In addition these products are called sulphurs, especially because they are likely to be 'abstracted [extracted] and separated from the rest of the Masse by Spirit of Wine [alcohol]' (259.23-24). He explains that those who make the connection between sulphur-containing bodies and solubility in alcohol, is that, as alcohol is highly inflammable, it is therefore 'Sulphureous' (259.26), and, 'they conclude, that what it works upon, and Abstracts [extracts], must be a Sulphur also' (259.26-28). Consequently, 'they presume, that they can sequester [separate] the sulphur even of Minerals and Metalls' (259.28-29 – 260.1), but it is known that fire alone cannot separate out the sulphur from these.

Carneades replies to this line of reasoning by arguing that if the sulphurs of bodies could indeed be extracted from them, then these products would show as great a variation between each other as exists in the oils obtained by distillation. He says that if 'these sequestred [separated] substances' (260.4-5) were really the sulphurs of their parent bodies, there would also exist 'a great Disparity [between] Chymical Sulphurs obtain'd by Spirit of Wine [alcohol], as I have already shewn [shown] there is [between] those obtain'd by Distillation in the forme of Oyles' (260.7-11).

Looking at the question from the point of view of the medicinal qualities of various plant and mineral extracts, Carneades notes – though does not stress – that the Paracelsians accord different medicinal properties to different metal and mineral extracts. He observes that when vegetables are extracted with alcohol and distilled, different ones do indeed yield different medicines, although he acknowledges that the medicinal powers of the various extracts may be poorer than imagined by their proponents.

Carneades relates this argument to the one just given on the differences between the sulphurs and the oils of different materials, saying that it will ‘be evident from hence, that not to urge [claim pressingly] that themselves ascribe distinct vertues [powers] to Mineral Tinctures’[72] (260.12-14). They extol ‘the Tincture of Gold against such and such Diseases’ (260.14-15), that of antimony, ‘or its Glass [fused antimony oxysulphide], against others’ (260.16-17). He continues that ‘’tis plain, that in Tinctures drawn from Vegetables, if the superfluous spirit of Wine [alcohol] be distill’d off’ (260.18-20), a thicker residue is left at the bottom of the retort, ‘which Chymists use to [used to] call the Extract of the Vegetable’ (260.22-23). The limited efficacy of such extracts is noted by Carneades, who says that they are ‘endow’d with very differing Qualities according to the Nature of the Particular Bodies that afforded [yielded] them’ (260.24-27), which is ‘freely confess’d [declared] both by Physitians [physicists] and Chymists’ (260.29 – 261.1), but he adds ‘though I fear seldom with so much of the specific vertues [qualities] as is wont [customarily] to be imagin’d’ (260.27-29).

Carneades follows this by saying that the ‘Chymists’ (261.3) are here, as in many other cases, allowing themselves ‘a License to abuse Words’ (261.5-6). He elaborates on this by pointing up inconsistencies in their reasoning. He argues that they will not accept from the ‘differing properties of Tinctures’ (261.7) that these are ‘pure and Elementary

[72] Tincture may be used here in its alchemical sense: a supposed spiritual or immaterial substance whose character or quality may be infused into material things, which are then said to be tinctures.

Sulphurs' (261.8-9), even though they argue that 'we should allow Chymical Oyles to deserve that Name' (261.11-12). He goes on to say that in 'some Mineral Tinctures[73] the Natural fixtness [inertness] of the extracted Body does not alwayes suffer [allow] it to be easily further resoluble [resolvable] into differing substances' (261.12-16).

He contrasts this with the behaviour of vegetables when analysed. He says that in 'very many extracts drawn from Vegetables' (261.16-17), it is easy to manifest or show plainly that 'the spirit of Wine [alcohol] has not sequestred [separated] the sulphureous Ingredient from the saline and Mercurial ones' (261.18-21). Rather than separating the products of plant decomposition into the three Paracelsian principles, it has instead dissolved 'the finer Parts of the Concrete [compound body]' (261.22-23) into what Carneades regards as a solution, and 'united it self with them into a kind of Magistery'[74] (261.25-26), which, he explains, 'consequently must contain ingredients or Parts of several sorts' (261.27-28). He adds '(without making any nice [strict, particular] distinction of their being perfectly Sulphureous or not)' (261.23-25). What Carneades seems to mean is that the solvent alcohol dissolves out all of the ingredients soluble in that solvent and, without any distinction between them, forms a common solution of them, which solution could not be separated into component parts.

He goes on to speak of 'stones that are rich in Vitriol [ferrous sulphate]' (261.29) 'being often drench'd with rain-Water, the Liquor will then extract a fine and transparent substance coagulable into Vitriol' (262.1-4). What Carneades is referring to here is iron

[73] This may be a reference to a coloured metal salt.
[74] A magistery is composed of the original elements of a body, freed from impurities.

pyrites or marchasites which are naturally occurring ferrous sulphates, and which in contact with air and water, gradually result in the formation of ferrous sulphate or vitriol, which itself can be dissolved in hot water and crystallised out as pure ferrous sulphate. Carneades argues that this water soluble vitriol 'is not a true Elementary Salt' (262.5-6), but is 'resoluble [resolvable] into very Differing Parts' (262.7-8). One such part 'as I shall have occasion [opportunity] to tell You anon [in a short while]' (262.8-9), 'is yet of a Metalline, and consequently not of an Elementary Nature' (262.9-11). What he may be referring to here is the fact that ferrous sulphate when burned forms ferric oxide,[75] which obviously contains iron, in that it can be heated with a fuel such as charcoal and be reduced to the metal.

He gives a further example – that of 'common Sulphur' (262.12) which 'is readily dissoluble [soluble] in Oyle of Turpentine'[76] (262.12-13), which 'notwithstanding its Name it abounds as well, if not as much, in Salt as in true Sulphur' (262.14-16). His evidence of this is 'the great quantity of saline Liquor it affords being set to flame away under a glasse Bell' (262.16-18). What Carneades seems to be arguing here is that sulphur, although now recognised as an element, was not regarded as one by him, nor as a principle, his reason being that when sulphur is set alight in a small space the sulphur dioxide formed will, in the presence of sunlight, form sulphur trioxide, and which dissolves in water to form sulphuric acid. This latter product is for him a saline as much as a sulphurous material. Carneades would have known that this process was employed

[75] See: Partington, *General and Inorganic Chemistry*, 856.
[76] He probably means by Oyle of Turpentine what is now called 'turpentine'.

as a route for synthesising sulphuric acid, so called *per campanum*, that is under a glass bell.

He next remarks how ‘Oyle of Turpentine alone easily enough dissolv’d crude Antimony finely powder’d into a Blood-red Balsam’[77] (262.20-22) and which may be of value in surgery. Carneades could continue in similar vein it if ‘were not now Requisite [appropriate]’ (262.25) to relate how some other bodies, including some surprising ones, that he has been ‘able to work upon with certain Chymical Oyles’ (262.28-29). Instead, he will further discuss the example already given. His argument is that alcohol is as much saline as sulphurous in nature, which would serve to enhance its solvent powers. He says that it is likely ‘that Spirit of Wine [alcohol] which by its pungent tast, and by some other Qualities that argue it better (especially its Reduciblenesse according to *Helmont,* into *Alcali*, and Water,)[78] seems to be as well [to the same extent] of a Saline as of a Sulphureous Nature’ (263.3-8). Carneades supposes that alcohol may well dissolve materials ‘That are not meerly [simply] Elementary sulphurs’ (263.10-11) but may contain sulphur-like portions, or as he himself puts it ‘though perhaps they may abound with Parts that are of kin [related] thereunto.

[77] What Carneades may have in mind here is ‘Red Antimony’ or Kermesite (a name employed only since 1832) which is an antimony oxysulphide, and is a native antimony mineral of a cherry-red colour. A balsalm is any of various fragrant oleoresins, obtained from any of several trees and shrubs and used as a base for medicines and perfumes.

[78] Although he is not claiming it at first hand, Carneades knew that spirit of wine or alcohol when in contact with the air is converted, ultimately, into acetic acid, and not into an alkali, as claimed by van Helmont.

He lists some materials which alcohol dissolves: ‘Spirit of Wine [alcohol] will dissolve *Gumm Lacca*[79][gum lac], *Benzoine*[80], and the *Resinous* Parts of *Jallap*[81], and even of *Guaiacum*’[82] (263.14-16). From these examples Carneades infers that alcohol may well ‘extract substances that are not perfect Sulphurs but mixt Bodies’ (263.19-21) ‘from Spices, Herbs, and other lesse compacted Vegetables’ (263.17-19). The proof of this is that in ‘many a Vulgar [common, ordinary] Extract drawn with Spirit of Wine [alcohol]’ (263.22-23), which distillation ‘will afford [yield] such differing substances’ (263.24-25) as clearly demonstrate that it was ‘a very compounded Body’ (263.26).

Continuing with this line of reasoning Carneades says that it is acceptable to suspect ‘that even in Mineral Tinctures’ (263.27-28), by which he seems to mean coloured inorganic compounds, ‘it will not alwaies follow, that because a red substance is drawn from the Concrete [compound material] by spirit of Wine [alcohol], that Substance is its true and Elementary Sulphur’ (263.28-29 – 264.1-3). He reinforces his point by speaking of the degree of flammability of such extracts, linking this to their putative sulphur content. He says that ‘though some of these Extracts may perhaps be inflamable; Yet besides that others are not’ (264.3-5), and that these latter products when ‘reduc’d to such Minuteness of Parts’ (264.6-7) may increase their inflammability. He then lists some materials: ‘common Sulphur, common Oyle, Gumm Lac,[83] and many

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[79] The dark red resinous incrustation produced on certain trees by the puncture of an insect *Coccus* (or *Carteria*) *lacca*, used in the East as a scarlet dye. Shellac is derived from it.
[80] A dry and brittle resinous substance, with a fragrant odour and slightly aromatic taste, obtained from the *Styrax benzoin*, used in medicine and perfumery, also called Benjamin.
[81] A purgative drug obtained from the tuberous roots of *Exogonium* (*Ipomoea*) *Purga*, and some other convolvulaceous plants.
[82] The resin of the *Guaiacum officinale* tree.
[83] The dark red resinous incrustation produced on certain trees by the puncture of an insect *Coccus* (or *Carteria*) *lacca*, used in the East as a scarlet dye. Shellac is derived from it.

Unctuous [oily] and Resinous Bodies, will flame well enough, though they be of very compounded natures' (264.9-13). He underscores the flammability of resinous materials by citing the evidence of 'Travellers of Unsuspected [not considered to be doubtful] Credit' (264.13-14) who affirm that 'in some Northern Countries where Firr trees and Pines abound' (264.15-17), 'Long splinters of these Resinous Woods' (264.18-19) are burnt by the poorer people instead of candles.

Carneades appears to have the patience, but not the time, to explain that sulphur is not the agent responsible for the red colouration of chemical compounds. He confidently states that he 'could easily shew [show]' (264.21-22) that it is not necessary that the red coloration observed in some alcoholic solutions 'should proceed from the Sulphur of the Concrete [compound material], Dissolv'd by the Spirit of Wine [alcohol]' (264.22-24). He does not have 'leasure to manifest [show plainly] how much Chymists are wont [accustomed] to delude themselves and others by the Ignorance of those other causes upon whose account spirit of Wine [alcohol] and other *Menstruums* [solvents] may acquire a red or some other high colour' (264.25-29 – 265.1). What Carneades seems to mean here is that the true explanation for the presence of colour in materials remains unknown to those who prepare solvent extracts of those materials, and that this situation will obtain for so long as sulphur is accepted as the agent responsible for it.

He immediately reverts to speaking of 'our Chymical Oyles' (265.2). His argument now concerns the high inflammability of these liquors, by which he means that in combustion an oil is converted into a flame. Such a transformation should not be possible, he argues, as it would involve transmutation of one principle into another, which he believes is not accepted as possible by ‘most Chymists’ (265.12). He will not tolerate a claim that the oil in burning does not really disappear into flame but instead can still be retrieved, as such retrieval has not yet been demonstrated.

Carneades begins by imagining ‘Chymical Oyles’ (265.2) as ‘exactly pure’ (265.3), which would render them inflammable, though not as highly so ‘as the best spirit of Wine [alcohol] is, but [only] the more inflammable and deflagrable [bursting into flame, and burning away rapidly]’ (265.4-6). He now states his core argument: ‘since an Oyle can be by the Fire alone immediately turn’d into flame, which is something of a very differing Nature from it’ (265.7-10) he will demand ‘how this Oyle can be a Primogeneal [primary] and Incorruptible Body, as most Chymists [Paracelsians] would have their Principles’ (265.10-13).

He concedes that the Aristotelians would see such a change as a transmutation of the oily liquor (or, in their eyes, as consisting mainly of the element water) into another element – Fire – but even so this ‘portion of the Element of Fire’ (265.15-16) ‘is certainly something of a very differing Nature from a Chymical Oyle (265.17-18). The evidence of its fiery nature is that ‘it burnes, and shines, and mounts swiftly upwards’ (265.19-20), none of which occurs with a ‘Chymical Oyle’ (265.20-21) ‘whilst it continues such’ (265.21). Carneades forestalls any claim that the ‘Dissipated Parts of this flaming Oyle may be caught and collected again into Oyl of Sulphur’ (265.23-25) by asking: ‘what Chymist appears to have ever done it’ (265.25-26).

Carneades counters any suggestion that fire and sulphur are really the same element by arguing that if such were the case then they would not be truly elemental. He avoids examining the proposition that it may therefore be ‘as well [in the same way] said that sulphur is but compacted Fire, as that Fire is but [merely] diffus’d Sulphur’ (265.28-29 – 266.1) by retorting that one could ‘consider whether it may not hence be argu’d, that neither Fire nor Sulphur are primitive and indestructible Bodies’ (266.2-4).

His final argument in this regard is made by positing that fire itself is an effective agent of change in materials, for he holds as a foundational tenet that all material things are specified by matter and motion. Hence a change to the structure and motion of a body at the most fundamental level, brought about by the fire, can effect a change greater than that which would differentiate the ‘Chymists Principles from one another’ (266.14-15).

Carneades now goes on to discuss the putative presence of mercury as a separate principle in compound materials. He begins by wishing to consider whether in the ‘Anatomy [chemical analysis] of mixt Bodies, that which Chymists call the Mercurial part of them be un-compounded [unmixed], or no’ (266.17-19). He acknowledges that ‘though Chymists do Unanimously affirm’ (266.20-21), that their ‘Resolutions [separations] discover [reveal] a Principle’ (266.21-22), namely their ‘Mercury’ (266.23). However, their descriptions of it are ‘so Differing, and so Aenigmaticall [obscure, perplexing] that he simply must admit that he knows ‘not what to make of them’ (266.28-29), as he ‘cannot understand what is not sence’ (266.26-27).

He says that '*Paracelsus* Himself' (266.29) and understandably 'many of his Followers' (267.1-2), somewhere calls 'Mercury' (267.3) that 'which ascends upon the burning of Wood, as the Peripateticks [Aristotelians] are wont [accustomed] to take the same smoke for Air' (267.3-6). From this he infers that Paracelsus 'seems to define Mercury by Volatility, or (if I may coyne such a Word) Effumability'[84] (267.6-8). But Carneades is having none of it, countering that 'in this Example, both Volatile Salt and Sulphur make part of the smoke, which does indeed consist also both of Phlegmatick [aqueous] and Terrene [earthy] Corpuscles, this Notion is not to be admitted [accepted]' (267.9-13). He does acknowledge that 'the more sober [sensible] Chymists themselves disavow [deny] it' (267.14-15).

However, even such Chymists or the 'latter *Spagyrists*' (267.17) one might note that '*Beguinus*[85] even in his *Tyrocinium Chymicum* [Chemistry for Beginners], written for the Instruction of Novices' (267.18-20), in his definition of the '*Tria Prima* [salt, sulphur and mercury] which for their being Principles ought to be defin'd the more accurately and plainly, gives us this Description of Mercury' (267.22-25), which may be translated as:

[84] The OED online (consulted 26-2-13) defines 'effumability' as a nonce-word and obsolete, quoting Boyle's present usage as its example, and giving it the meaning 'Capability of being converted into vapour'.

[85] Jean Beguin, French-born medic and chemist, follower of Paracelsus. His *Tyrocinium Chymicum* [Chemistry for Beginners] was published in 1610.

> 'Mercury (sayes he) that well known acid liquor, pervading, penetrable, etherial, and besides, most pure, by which all sustenance, sensation, motion, strength, colour, age and precipitate action is retarded' (267.25-29 – 268.1).[86]

Carneades adds tartly that the above description is not so much 'a Definition of it [mercury], as an *Encomium* [a formal or high-flown expression of praise]' (268.1-2), adding that '*Quercetanus*'[87] (268.3), in similar vein, 'adds to these, divers [several] other *Epithets*' (268.4-5). He means by this word, adjectives indicating some qualities or attributes which the speaker or writer regards as characteristic of, in this case, mercury. Even in overlooking 'very many other faults' (268.6) accompanying 'their Metaphoricall [not literal] Descriptions, speak incongruously [inconsistently] to the Chymists own Principles [salt, sulphur, mercury]' (268.7-9). Carneades reasons that one cannot posit mutually exclusive qualities to the same material, saying that if mercury 'be an Acid Liquor, either Hermetical Philosophy [alchemy or chemistry] must err in ascribing all Tasts to Salt, or else Mercury must not be a Principle, but Compounded of a Saline Ingredient and somewhat [something] else' (268.10-15). He then contrasts the opinions of two near contemporary writers on the subject, saying that '*Libavius*[88] though he find [finds] great fault with the obscurity of what the Chymists write concerning their Mercurial Principle, does not but [only] give us such a Negative Description of it, as *Sennertus*[89] how [however] favourable soever to the *Tria Prima* [salt, sulphur, mercury] is not Satisfi'd with' (268.15-21). He continues that Sennert,

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[86] ' *Mercurius* (sayes he) *est liquor ille acidus, permeabilis, penetrabilis, aethereus, ac purissimus, a quo omnis Nutricatio, Sensu* [corrected to *Sensus* in the 1680 Edition]*, Motus, Vires, Colores, Senectutisque Praeproperae retardatio*.'

[87] Joseph du Chesne (1521/44-1609) French-born Paracelsian and physician.

[88] Andreas Libavius [Andreas Libau] (1555-1616) German-born chemist and alchemist. His *Alchymia* [alchemy], from 1606, is regarded by some as the first modern chemical textbook.

[89] Daniel Sennert (1572-1637) German-born physician and chemist. He accepted Paracelsus' theory of salt, sulphur and mercury as the three principles, but rejected other parts of Paracelsus' doctrines.

'though the Learnedest Champion for the Hypostatical [elemental] Principles' (268.22-24), *i.e*. salt, sulphur and mercury, often rightly, complains of the Paracelsians' doctrine 'concerning their Mercury' (268.27). Yet, he says, Sennert, with 'wonted [customary] modesty' (268.28) 'Substitutes instead of the Description of *Libavius*, another, which many Readers' (268.29 – 269.1-2) will not understand, particularly those who are not 'Peripateticks [Aristotelians]' (269.2-3). He then explains that Sennert speaks of a spirit which, because of its mystical context, Carneades is unwilling to accept as satisfactory or comprehensible. This spirit is supposed to be found in all bodies 'besides Salt and Sulphur, and the elements, or as they call them, Phlegm [aqueous fraction] and Dead Earth' (269.6-8), and 'which in *Aristotles* Language may be call'd οὐσίᾱ ἀνάλογος των ἄστρων στοιχείῳ[90] [a substance analogous to the stellar element]' (269.8-10). This account from Sennert 'is not at all satisfactory' (269.11-12) to Carneades, who is unwilling 'to seem to acquiesce in any mans Mystical Doctrines' (269.12-14) for fear of being 'thought to understand them' (269.14-15).

Eleutherius interjects a hypothetical point of view, arguing that those who accept the three Paracelsian principles believe the mercury of a body as being separate from its salt and sulphur, and that such an opinion would make sense to them. He begins by supposing that if 'I durst[dared] presume that the same thing would be thought clear by me' (269.16-18) as well as 'those that are fond of such cloudy Expressions as You justly Tax [blame] the Chymists [Paracelsians] for' (269.18-20), then he would 'venture to offer to Consideration' (269.20-21) this belief, and whether it is so. His justification for

[90] Greek text taken from the 1744 edition, as the text in the 1661 edition seems to be corrupt. See: Birch, ed.,*Works*, 1: 342.

this is 'since the Mercurial Principle that arises from Distillation is unanimously asserted to be distinct from the salt and Sulphur of the same Concrete [compound body]' (269.22-25). Even though the 'Mercurial Principle' (269.22) ascends during distillation 'as do the Phlegme [aqueous fraction] and Sulphur' (269.28), it 'is neither insipid [having little or no taste] like the former, nor inflamable like the latter' (269.28-29 – 270.1).

He reasons that he would therefore 'substitute to the too much abused Name of Mercury, the more clear and Familiar Appellation [name] of Spirit' (270.2-4), which he states is now also much employed even by the present-day 'Chymists themselves' (270.6). He remarks that they have not supplied 'so Distinct an Explication, as were fit, of what may be call'd the Spirit of a mixt Body' (270.8-10).

Carneades now speaks, stating his general agreement with his interlocutor on mercury, but raises an objection as to what exactly his adversaries can identify as a mercury of an organic material, and what constitutes a saline body. He begins by wondering what the 'Chymists' (270.13) 'can mean, with congruity [coherence] to their own Principles, by the Mercury of Animals and Vegetables' (270.14-16), adding that this will 'not be so Easie to find out' (270.17). He goes on to develop this point by stating that 'they ascribe Tasts only to the Saline Principle' (270.17-18) but, 'consequently would be much put to it [find it difficult] to shew [show] what Liquor it is' (270.19-20), in decomposed materials. He says that as it is not insipid, it cannot be what 'they call Phlegme [aqueous]' (270.22). Neither is it 'inflamable as Oyle or Sulphur' (270.23), nor does it have 'any Tast' (270.24), 'which according to them must proceed from a Mixture, at least, of Salt' (270.24-26).

Shifting his attention now to 'Spirit' (270.27) in its definition 'among Modern Chymists and Physitians [physicists], for any Distill'd Liquor that is neither Phlegm [aqueous fraction] nor oyle' (270.28-29 – 271.1), the 'Appellation' (271.1-2), or name, would still be rather ambiguous. The reason is that that which 'first ascends in the Distillation of Wine and Fermented Liquors, is generally as well by Chymists as others reputed a Spirit' (271.3-7). Yet the 'wholly inflamable' (271.8) *i.e.* burning away completely, 'Spirit of Wine [alcohol]' (271.7) should really be classified by them as being of the 'Sulphureous, not the Mercurial Principle' (271.9-10).

In addition, among other liquors which are classified as spirits 'there are divers [many] which seem to belong to the family of Salts, such as are the Spirits of Nitre [nitric acid], Vitriol,[91] Sea-Salt [hydrochloric acid] and others' (271.12-15). In addition the Spirit of Harts-horn [ammonia solution]' (271.16) which is largely 'reducible into Salt and Phlegme [here: water]' (271.18), by which he means that the ammonia can be driven out of the solution by heat. He correctly suspects that ammonia solution is 'but a Volatile Salt [ammonia] disguis'd by the Phlegme [here: water] mingl'd with it into the forme of a Liquor [here: ammonia solution]' (271.19-21).

He correctly notes that if 'this [ammonia] be a Spirit, it manifestly [obviously] differs very much from that of Vinager [acetic acid vapour], the Tast of one being Acid, and the

[91] Probably sulphuric acid prepared by distilling iron sulphate.

other Salt [actually: alkaline]' (271.22-25). Carneades goes on to observe that 'their Mixture in case they be very pure, sometimes occasioning an Effervesence [bubbling up] like that of those Liquors the Chymists count most contrary to one another' (271.25-29). He is here referring to the neutralisation reaction which results when the acidic acetic acid reacts with the basic ammonium hydroxide to form ammonium acetate. He points out that 'even among those Liquors' (271.29 – 272.1) which are more entitled to be called spirits than those already mentioned 'there appears a sensible [evident] Diversity' (272.3-4). He continues that 'spirit of Oak, for instance, differs from that of Tartar[92], and from that of Box, or of *Guaiacum.*[93] Curiously, the three types of wood mentioned here would each yield much the same decomposition products, with acetic acid and methanol being the most important in percentage terms. He concludes that 'even these spirits as well as other Distill'd Liquors manifest [show] a great Disparity - [between] themselves' (272.7-9), either in their behaviour on our senses, or otherwise.

Carneades makes another reference to the 'Modernes' (272.14) and the 'Disparity' (272.13) to be found 'among those Liquors' (272.13-14) that they 'call spirits, & take for similar bodies' (272.15). He reminds his interlocutor about 'the Spirit of Box-wood'[94] (272.16-17). He says not only that 'some of those Liquors not only have qualities very differing from others, but may be further resolved into substances differing from one another' (272.18-21).

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[92] Spirit of Tartar is a liquid obtained by the dry distillation of tartar (which itself is deposited during the production of wine) and contains pyrotartaric acid as well as other products.
[93] *Guaiacum officinale* and *Guaiacum sanctum* – hard, heavy brownish-green woods, used in medicine, also called *Lignum vitae* = wood of life.
[94] Discussed on pp. 192-193.

Shifting now to discussing mercury and the practice among ‘moderne Chymists and other Naturalists [scientists]’ (272.22-23) of taking ‘the Mercurial spirit of Bodies for the same Principle, under differing names’ (272.24-25), he draws attention to the ‘great difference that is conspicuous [between] all the Vegetable and Animal spirits I have mention’d and Mercury’ (272.27-29 – 273.1). He is quick to point out that he does not mean the mercury ‘sold in shops’ (273.2) which chemists ‘confesse [acknowledge] to be a mixt Body’ (273.3-4), but rather ‘that which is separated from Metals’ (273.4-5) and which ‘*Claveus*’[95] (273.8) and ‘some Chymists that seem more Philosophers, then [than] the rest’ (273.5-7), called ‘*Mercurius Corporum* [mercury of bodies]’ (273.9).

He goes on to speak of ‘this Metalline Liquor’ (273.9-10), one of the ‘three Principles’ (273.10-11) which the *Spagyrists* [Paracelsians] assert minerals to be composed of, and into which they can be decomposed. Yet ‘the many notorious [well known] Differences [between] them and the Mercuries, as They call Them, of Vegetables and Animals’ (273.13-16) causes him to infer one of two things: the first possibility is that minerals, plants and animals are not composed of the same elements, the second, that the ‘Principles whereinto Minerals are immediately [directly] resolved’ (273.20-21) which although the ‘Chymists [Paracelsians] with great ostentation [vulgar show] shew [show] us as the true principles,[96] of them’ (273.21-23) are only ‘Secundary Principles, or Mixts of a peculiar [distinctive] sort’ (273.23-24). These of necessity must be ‘reduc’d to a very differing forme, to be of the same kind [nature] with Vegetable and Animal Liquors’ (273.25-28).

[95] Gaston de Claves, or Gaston Duclo, or Le Doux, born *c*. 1530, French lawyer and chemist, whose experiments on the volatility of silver and gold are recounted on pp. 56-57.
[96] This comma removed in the 1680 edition.

Carneades adopts a tone somewhere between exasperation and genuine curiosity in which he invites proof of the production of the mercuries of metals, reflecting that even if such substances were produced they would differ, not just from common mercuries but from the analogous mercuries of vegetable and animal origin. He goes on to mention that although he has 'formerly told You how Little Credit there is to be given to the Chymical Processes' (273.29 – 274.2) usually employed to extract 'the Mercuries of Metals' (274.4), he asks that 'supposing that the more Judicious [prudent] of them do not untruly affirme that they have really drawn true and running Mercury from several Metals' (274.5-8). He adds '(which I wish they had cleerly taught Us how to do also,)' (274.9-10), yet there persists the doubt 'whether such extracted Mercuries do not as well [to the same extent] differ from common Quicksilver [mercury], and from one another, as from the Mercuries of Vegetables and Animalls' (274.11-15).

He continues that '*Claveus*',[97] in his Apology, speaking of some *experiments* whereby Metalline Mercuries may be fixt into the nobler metals [*i.e*. gold and silver]' (274.15-21) and in italicising the word 'experiments' Carneades seems to be granting the experimenter the status of having manipulated materials in his laboratory which yielded products of which he had to give a systematic account. He quotes Claveus as having differentiated between the mercuries obtained from metals and the familiar, heavy, silvery metallic liquid, some of whose properties, he contends, rendering it unsuitable for the process in question.

[97] Gaston de Claves, or Gaston Duclo, or Le Doux, born *c*. 1530, French lawyer and chemist.

Carneades says that Claveus 'spake [spoke] of the Mercuries drawn from metals; because common Quicksilver [mercury]' (274.22-24) is ruled out of the process due to its excessive coldnesse and moisture' (274.24), although Carneades leaves unchallenged this reason for excluding common mercury from the operation, adding simply that Claveus shortly before 'prescribes in general the Mercuries of Metalline Bodies, yet he chiefly commends that drawn by art from silver' (274.27-29).

He goes on to mention Claveus's own experiment in which by bare [mere] coction [by the action of heat] the quicksilver [mercury] of Tin or Pewter [an alloy of tin and lead] (*argentum vivum ex stanno prolicitum* [the quicksilver [mercury] drawn from tin]) may by an efficient cause'[98] (275.2-5) 'be turn'd into pure Gold' (275.5-6). He then relates how 'the Experienc'd *Alexander van Suchten*'[99] (275.6-7) says 'that by a way he intimates may be made a Mercury of Copper, not of the Silver colour of other Mercuries, but green' (275.8-11). What seems to have been produced was simply a green-coloured copper compound. Carneades then speaks of 'an eminent person' (275.11) – a writer and traveller – who 'lately assur'd me that he had more then [than] once seen the Mercury of Lead' (275.14-16) 'fixt into perfect Gold' (275.19), which he adds one will not easily produce in 'any considerable quantity' (275.18-19). When Carneades 'demanded whether or no any other mercury would not as well have been changed by the same Operations, he assured me of the Negative' (275.20-23).

[98] One of Aristotle's four causes: the material, formal, efficient and final, corresponding to his four kinds of explanation.

[99] Probably Alexander von Suchten, *fl*. second half of 16th century, German-born physician and chemist, who wrote 'Of the Secrets of Antimony'.

Carneades goes on to say that ‘since I am fallen [settled] upon the mention of the Mercuries of metals’ (275.24-25) that Eleutherius might expect him to discuss the ‘two other principles’ (275.27-28) namely, salt and sulphur. He admits that whatever ‘Disparity there may be between the salts and sulphurs of Metals and other Menerals’ (275.29 – 276.1-2) he is not in a position to determine as he is not ‘experienced enough in the separations and examens [examinations] of them’ (276.3-4). He adds as an afterthought, that he has ‘formerly represented [asserted] it as a thing much to be question’d’ (276.6-7) whether salts of metals actually exist.

Carneades raises an operational difficulty to be encountered in the separating of principles: such procedures, if they are to be successful, must involve the use of other chemical compounds which themselves would be likely to interact with the putative principles, whether by chemical reaction or otherwise, and render it difficult to positively identify them. He begins by saying that ‘the processes of separation I find in Authors’ (276.8-9), many of which, as already mentioned by him, are not ‘successfully practicable’ (276.10), as these procedures ‘are to be performed by the assistance of other bodies’ (276.11-12), which are unlikely to be separable from them, so much so, ‘that it is very difficult to give the separated principles all their due, and no more’ (276.14-16).

He goes on to give some examples of the sulphur obtained from (what are in fact sulphur containing minerals) which is, he asserts, different from that obtained from materials of vegetable origin. He mentions two types of sulphur: the ‘Sulphur of Antimony which is vehemently vomitive [causing vomiting]’ (276.16-18), that is, the sulphur obtained by the decomposition of antimony sulphide or stibnite, 'and the strongly scented Anodyne [pain alleviating] Sulphur of Vitriol [ferrous sulphate]' (276.18-19), namely sulphur obtained by the decomposition of ferrous sulphate. These products incline him 'to think that not only mineral sulphurs differ from Vegetable ones, but also from one another, retaining much of the nature of their Concrete [compound materials]' (276.19-21). This would be the case as the sulphurs in question are what are now recognised as chemical compounds of the element sulphur.

Carneades next turns to the 'salts of metals, and of some sort of minerals' (276.23-24), which he says his interlocutor 'will easily guesse (by the Doubts I formerly express'd, whether metals have any salt at all)'[100] (276.25-27), which, despite his curiosity, he has not seen as yet. He now invokes the name of Paracelsus as expressing opinions in his writings which concur with those of Carneades regarding the differences between metal and mineral salts. He prefaces a relevant passage from Paracelsus by saying that if the latter 'did alwaies write so consentaneously [agreeably] to himself that his opinion were *confidently* to be collected from every place of his writings where he seems to expresse it' (276.29 – 277.1-4) that he 'both countenances [bears out]' (277.5-6) what Carneades has already said in his 'Fourth main consideration' (277.7), and especially, warrants him 'to suspect that there may be a difference in metalline and mineral Salts, as well as [as much as] we find it in those of other bodies' (277.8-11). He quotes a passage from Paracelsus, which may be translated as:

> 'For, Sulphur (sayes he) there is one in gold, another in silver, another in iron, another in lead, tin, etc., so, another in sapphire, another in emerald, another in

[100] Brackets added in *Errata*.

> ruby, topaz, amethyst, loadstone, etc. Similarly one in stones, silica, salts, springs, etc., and not just the same number of sulphurs, but the same number of salts as well; another sulphur in metals, another in gems, another in stones, another in salts, another in vitriol, another in alum: and indeed the same rationale applies to mercury. Another in metals, another in gems, etc. It is thus, just as though each species had its own particular mercury. And nevertheless the saline properties are three in number: one essence is sulphur, one is salt, and one is mercury. I would add that more particular to this point is that every individual thing can be divided; certainly gold is not simple, but complex, and also a pear or an apple is not simple, but it too is complex; besides there are as many sulphurs of gold, salts of gold, mercuries of gold; also the same holds true for metals and gems; in the same way that there are sapphires both more excellent and more polished, etc., there are also as many sapphire sulphurs, sapphire salts, sapphire mercuries, etc., the same too is the case for turquoises and for all other gems taken together' (277.11-29 – 278.1-7).[101]

Carneades supposes that his interlocutor will reasonably conclude one of two things: that Carneades' 'opinion is favoured by that of *Paracelsus*, or that *Paracelsus* his opinion was not alwaies the same' (278.10-12). He makes the point that as Paracelsus is

[101] ' For, *Sulphur* (sayes he) *aliud in auro, aliud in argento, aliud in ferro, aliud in plumbo, stanno, &c. sic aliud in Saphiro, aliud in Smaragdo, aliud in rubino, chrysolito, amethisto, magnete, &c. Item aliud in lapidibus, silice, silibus, fontibus, &c. nec vero tot sulphura tantum, sed & totidem salia; sal aliud in metallis, aliud in gemmis, aliud in lapidibus, aliud in salibus, aliud in vitriolo, aliud in alumine: similis etiam Mercurii est ratio. Alius in Metallis, alius in Gemmis, &c. Ita ut unicuique speciei suus peculiaris Mercurius sit. Et tamen res saltem tres sunt; una essentia est sulphur ; una est sal; una est Mercurius. Addo quod & specialius adhuc singular dividantur ; aurum enim non unum, sed multiplex, ut et non unum pyrum, pomum, sed idem multiplex; totidem etiam sulphura auri, salia auri, mercurii auri; idem competit etiam metallis & gemmis; ut quot saphyri praestantiores leviores, &c. tot etiam saphyrica sulphura, saphyrica salia, saphyrici Mercurii, &c. Idem verum etiam est de turconibus & gemmis aliis universis.*'

inconsistent in what he says about his own three principles and the four Aristotelian elements, he will infer from the passage just quoted, that if Paracelsus' doctrine does not agree with that of Carneades, it becomes difficult to determine his opinion on his three principles. He says that because in 'divers [several] other places' (278.13) in Paracelsus' writings he appears 'to talk at a differing rate [pace] of the three Principles and the four Elements' (278.14-15). Carneades allows himself 'to inferr from the alledg'd [quoted] passage' (278.16-17) that if his doctrine does not agree 'with that Part of mine which it is brought to countenance [bear out]' (278.18-19) it is very difficult to determine his opinion regarding 'salt, sulphur and mercury' (278.21). Consequently he feels justified when they decided as their 'conferences [discourses]' (278.23-24) began 'to decline taking upon us, either to examine or oppose it' (278.24-25).

He says that perhaps he should now add 'that those very [exact] bodies the Chymists call Phlegme [aqueous fraction] and Earth do yet recede [still depart] from an Elementary simplicity' (278.27-29), by which he seems to mean that these materials themselves are not sufficiently simple to be considered as elementary. He accepts that 'Earth and Water frequently do so' (279.1-2), that is, are regarded as elemental, despite 'the received contrary opinion' (279.2-3), and that this 'is not deny'd by the more wary [cautious] of the moderne Peripateticks [Aristotelians] themselves' (279.3-5). Carneades goes on to make the argument that earths are usually more complex than is believed by many, being employed in distillations as inert substances to act both as filters and as barriers to the free movement of the reactants. He says that 'most Earths are much lesse simple bodies then [than] is commonly imagined even by Chymists'

(279.5-7), explaining that they ‘do not so consideratly [deliberately] to prescribe and employ earths promiscuously [indiscriminately] in those distillations that require the mixture of some *caput mortuum* [here: inert substrate], to hinder the flowing together of the matter, and to retain its grosser [larger] parts [pieces]’ (279.8-13).

Carneades now quotes from his own experience, saying that he has ‘found some Earths to yield by distillation a Liquor very far from being inodorous [without odour] or insipid [without taste]’ (279.13-16). He adds that ‘’tis a known observation, that most kinds of fat Earth [earth containing much soluble matter]’ (279.16-17), if kept dry and not planted with vegetables, ‘will in time become impregnated with Salt-Petre [potassium nitrate or nitre]’[102] (279.20-21). He reminds himself that ‘the Water and Earths’ (279.22-23) he ought to consider ‘are such as are separated from mixt Bodies by the fire’ (279.24-25), and limiting himself to these says ‘That we see the Phlegme of Vitriol[103] (for instance) is a very effectual remedie against burnes’ (279.27-29). Carneades goes on to relate how a ‘very Famous and experience’d *Physitian* [natural philosopher or physicist]’ (279.29 – 280.1), who passed his ‘unsuspected [not considered doubtful] secret’ (280.1-2) on to Carneades, and it is ‘for the discussing [dispelling] of hard and Obstinate Tumours’ (280.3-4).

Carneades goes on to discuss another experiment in which the ‘Phlegme of Vinager [dilute acetic acid], though drawn exceedingly leasurly in a digesting Furnace’ (280.4-

[102] Saltpetre is a crystalline white solid which is continuously produced by nitrogenous organic matter as it decays. Being highly water soluble, the saltpetre can be removed by washing it out of the original material on which it forms. Hence the requirement to keep the organic material dry.
[103] The water of crystallisation collected by heating hydrated ferrous sulphate and condensing the liquid.

6), by which he seems to mean wine which has been left in contact with the air, in a low temperature furnace, allowing the alcohol of the wine to be oxidised to acetic acid. He found that this product was 'able to draw, though slowly, a saccharine sweetness out of Lead' (280.8-9). What Carneades seems to mean is that the acetic acid was so weak that it took a long time for it to react with lead to form the sweet-tasting lead acetate. He also recalls that 'by long Digestion, I dissolv'd Corpals[104] in it' (280.10-11), meaning that in dilute acetic acid, corals, consisting mainly of calcium carbonate, over time dissolve in it.

He continues that 'the Phlegme of the sugar of Saturne is said to have very peculiar properties' (280.11-13). He elaborates on this by adding 'Divers [several] Eminent Chymists teach that it will dissolve Pearls' (280.13-14). What Carneades seems to mean is that the liquor of a solution of lead acetate is capable of dissolving pearls, which consist mainly of calcium carbonate. The liquor itself, being a solution of the salt of a weak acid, would undergo hydrolysis to regenerate the original acetic acid, and this acidic solution might well be capable of dissolving bodies consisting of calcium carbonate. He then says of the pearls 'which being precipitated by the spirit of the same concrete [compound material] are thereby (as they say) rendred volatile' (280.14-17), and that this phenomenon has been confirmed to Carneades 'upon his own observation, by a person of great veracity' (280.18-19).

[104] Corrected to 'Corals' in the *Errata*.

What he may mean is that when lead acetate is dry distilled, first water, then acetone is liberated, which latter is a volatile solvent.[105] Carneades' informant may have added some acetone back into a mixture of calcium carbonate dissolved in lead acetate solution, and acetone, although miscible with water, is a non-solvent for calcium carbonate. It may have caused the calcium carbonate to precipitate out of solution. Hence the pearls dissolved in lead acetate solution are 'precipitated by the spirit of the same concrete' (280.15-16). That is to say, they are precipitated out of solution by the acetone, 'spirit', produced in dry distilling lead acetate 'the same concrete'. The precipitated calcium carbonate, the remnant of the original pearls, can be retrieved either by filtration or simply by pouring off the supernatant liquor, but it will still contain some of the acetone added to cause its precipitation out of solution. This residual acetone will evaporate off quite readily, especially on heating, and Carneades remarks on this by noting that the dissolved pearls 'are thereby (as they say) rendred volatile' (280.16-17).

He goes on to describe that 'The Phlegme of Wine' (280.19-20), possibly a water-rich fraction obtained in the distillation of wine, as well as 'divers [many] other Liquors that are indiscriminately [without distinction] condemnd to be cast away as phlegm [aqueous fraction], are endow'd with qualities that make them differ from meer [pure] water, and from each other' (280.20-24). He adds that 'whereas the Chymists are pleas'd to call the *caput mortuum*' (280.25-26), that is, the residue left on distillation, '*terra damnata* or Earth' (280.28-29), after they have 'by affusion [pouring on] of water drawn away its salt' (280.27-28), that is, after its soluble solid content has been dissolved out with water. He continues that it is doubtful whether 'those earths are all of them perfectly

[105] See: Partington, *History of Chemistry,* 2: 266.

alike' (281.1-2), adding that some of them most likely 'remain yet unreduc'd to an Elementary nature' (281.3-5).

He quotes as examples of these 'The ashes of wood depriv'd of all the salt' (281.5-6), by which he probably means wood ash with its soluble solids washed out of it, *i.e.* potassium carbonate, followed by 'bone-Ashes, or calcin'd Harts-horn' (281.6-7), both of which would consist mainly of calcium triphosphate. These 'Refiners choose to make Tests[106] of, as freest from Salt' (281.7-8), by which he probably means they contain the least amount of water-soluble residue (calcium triphosphate is almost insoluble in water) 'seem unlike' (281.8). And unalike they are, as calcium triphosphate is not simply distinct from potassium carbonate in its solubility, but also in its chemical properties. He goes on to admonish that 'he that shall compare either of these insipid [having little or no taste] ashes to Lime [here: quicklime or calcium oxide] and much more to the *calx* of Talk[107] (though by the affusion [pouring on] of water they are exquisitely [extremely well] dulcify'd [washed])' (281.8-12), by which he seems to mean when these two materials are hydrated by the addition of water. He adds that the experimenter 'will perhaps see cause to think them of a somewhat different nature' (281.12-14).

Carneades next avers that 'it is evident in Colcothar [an anhydrous salt] that the exactest calcination [strongest heating to dehydrate the salt], follow'd by an Exquisite [extreme]

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[106] Carneades is here referring to a 'test', or cupel, a small circular vessel made of compressed bone-ash, and in this case used in refining silver.

[107] Talc is a white or green form of hydrated magnesium silicate. The calx would have been formed by heating it strongly, to drive off its water of hydration.

dulcification [washing] does not alwaies reduce the remaining body into elementary earth' (281.14-18). He cites as an example 'the salt of Vitriol [here: the hydrated or partially-hydrated salt] (if the Calcination [here: heating process] have been too faint) is drawn out of the Colcothar [anhydrous salt]' (281.18-20), 'the residue is not earth, but a mixt body, rich in Medical vertues [properties] (as experience has inform'd me)' (281.21-23). He continues that '*Angelus Sala*[108] affirms it to be partly reducible into malleable Copper' (281.23-25). What Carneades seems to have in mind here is copper sulphate which when heated strongly produces an anhydride, and which when heated even more strongly with charcoal, for example, is reduced to the metal.

He considers this outcome 'very probable' (281.25-26), and goes on to demonstrate why he considers the colcothar or anhydrous salt to contain copper. When he 'was making Experiments upon Colcothar [here: anhydrous copper sulphate]' (281.26-27), he lacked a furnace which burned hot enough 'to bring such a Calx [here: the copper sulphate anhydrate] to Fusion' (281.29 – 282.1), that is, to melt it. Having 'conjectur'd that if Colcothar [here: anhydrous copper sulphate] abounded with that Metal, Aqua Fortis [nitric acid] would find it out there' (282.1-4). He put 'some dulcifi'd [here: washed] Colcothar [here: anhydrous copper sulphate] into that *Menstruum* [here: nitric acid]' (282.4-5). Just as he had anticipated, he found that the acid solution 'presently [immediately] Colour'd as Highly as if it had been an Ordinary Solution of Copper' (282.7-9). Of course what happened was that on placing the anhydrous copper sulphate into a nitric acid solution the anhydrous compound regained its water of crystallisation, and consequently its blue coloration.

[108] Angelus Sala (1570-1637) Italian-born physician and chemist.

A Commentary on
The Sceptical Chymist
of Robert Boyle:
The Fifth Part

Introductory Remarks

The central theme of this section of the book is that, to quote Boas (*q.v.*), 'Boyle explains why he thinks the doctrine of chemical elements an inadequate basis for a general chemical theory.' Carneades complains that the Paracelsian doctrine fails to explain such natural phenomena as magnetism, growth of poultry and plant formation (301), and further queries how its proponents account for the Architectonic Spirit, given that it informs the *tria prima* (302-303), and for the primary and secondary qualities of natural things (303). He notes the lack of consistency between different writers as to the composition of the *tria prima* (315-316), likewise disagreement among even acclaimed Paracelsians as to which of these three principles is responsible for colour (327-328).

Carneades explains that colour is a surface phenomenon and cannot be explained by recourse to the *tria prima* (328). He argues that the presence of material constituents alone in a given body is inadequate to account for its physical properties: the arrangement or structure of these same ingredients is essential in determining the qualities possessed by that body (340-341).

The Sceptical Chymist

The Fifth Part

Carneades pauses, and immediately his companion speaks, affirming his finding on the three principles of the Paracelsians. Eleutherius says that he will not deny that he believes 'You have sufficiently prov'd that these distinct Substances which Chymists are wont [accustomed] to obtain from Mixt Bodies, by their Vulgar [common] Distillation, are not pure and simple enough to deserve in Rigour [strict sense] of speaking, the Name of Elements, or Principles' (283.3-9). He qualifies his assertion by reminding Carneades that there are 'some Modern *Spagyrists* [Paracelsians], who give out [report]' (283.11-12) that, by more effective purifications, they can 'so reduce the separated Ingredients of Mixt Bodies to an Elementary simplicity' (283.13-15). So that, for example, all of the oils extracted from compound bodies are as alike 'as the Drops of Water' (284.3).

Carneades side-steps the claim made just now on behalf of the Paracelsians by his interlocutor, by saying that it is not now his intention to do any more than scrutinise the standard conclusions posited by them in favour of their three principles – this position being adopted by him on foot of a promise to the Paracelsian participant in the dialogue, namely Philoponus.

Carneades says that at this stage of the 'Conference [discourse]' (284.6) he 'declar'd' (284.7) to Philoponus before all those present that he 'would not *engage* my self at present to do any more then [than] examine the usual proofs alledg'd [cited] by Chymists, for the Vulgar [common] doctrine of their three Hypostatical [elementary] Principles [*i.e.* salt, sulphur and mercury]' (284.9-13). Consequently his companion will easily understand that Carneades is ‘not oblig’d to make answer to what you newly [very recently] propos’d’ (284.14-15), adding mischievously that in any event ‘it rather grants, then [than] disproves what I have been contending [arguing] for’ (284.15-17).

He justifies this by arguing that before any attempt to reduce different materials to a common composition is made through distillation, there must exist the belief that they are not yet of the ultimate degree of simplicity. He says that ‘Since by pretending to make so great a change in the reputed Principles’ (284.17-19) yielded by distillation to the ‘common *Spagyrists* [Paracelsians]’ (284.20) it is obviously taken for granted ‘that before such Artificial Depuration [refining] be made’ (284.21-22) the materials to be broken down ‘were not yet simple enough to be look’d upon as Elementary’ (284.24-25).

Carneades is careful to cover the eventuality that even if the Paracelsians succeed in purifying different materials so thoroughly as to cause them to seem alike, he feels justified in questioning the standard teaching regarding the three Paracelsian principles. He adds ‘Wherefore [for which] in case the *Artists* [skilled practitioners] you speak of could perform what they give out [proclaim] they can’ (284.25-27), he would still feel entitled to question the ‘Vulgar [common] Opinion touching the *tria Prima* [three principles]’ (284.29 – 285.1).

He then checks himself, sensibly stating his reluctance in judging things to be impossible until he has given attention to the proposed experimental means to be employed in establishing the case. As a result he will withhold judgement on any claims made, even at the expense of his own beliefs. He says ‘as to the thing it self’ (285.1-2) he really does not wish ‘to be forward [eager] in determining things to be impossible, till I know and have consider’d the means by which they are propos’d to be effected’ (285.3-7). Consequently, he will ‘not peremptorily [emphatically] deny either the possibility of what these *Artists* [skilled practitioners] promise, or my Assent to any just Inference’ (285.7-10). Carneades displays both his fair-mindedness and his conviction on this matter by adding ‘however destructive to my Conjectures, that may be drawn from their performances’ (285.10-12).

Lest he be considered a ‘soft-touch’ or a ‘pushover’ for swallowing wholesale Paracelsian ‘proofs’, he is quick to admonish ‘withall [in addition]’ (285.13) what he knows from experience ‘that because such promises are wont [customarily]’ (285.14) ‘to be much more easily made, then [than] made good by Chymists’ (285.16-17), he will not accept their claims ‘till their Experiments exact [require] it’ (285.19). He asserts his lack of gullibility by stating that he ‘must not be so easie [credulous] as to expect before hand, an unlikely thing upon no stronger Inducements [that which leads to a conclusion] then [than] are yet [already] given me’ (285.20-23).

Carneades makes a criticism of the practitioners of chemistry, accusing them of falsely claiming to employ fire, both to separate compound materials into different substances, but also to divide all types of compound bodies into the same number of decomposition products. In addition, they make the claim that the individual decomposition products can be highly refined by the fire. He says that he has ‘not yet found by what I have heard of these Artists’ (285.23-24) that ‘they pretend to bring' (285.25) various thermal decomposition products of the material 'to an exquisite [extreme] simplicity' (285.27-29). 'They pretend also to be able by the Fire to divide all Concretes [compound materials], Minerals, and others, into the same number of Distinct Substances' (285.28-29 – 286.1-2).

Carneades now draws on his knowledge of the decomposition products of a variety of materials, and of his understanding of which materials do not decompose into other products. In so doing he is able to express his doubts that the different materials yield exactly the same set of decomposition products, or that the mercury of a metal would be identical with that of an organic material. He avers that he considers it improbable that 'they can either truly separate as many differing Bodies from Gold (for instance) or *Osteacolla*,[1] as we can do from Wine, or Vitriol [ferrous sulphate]; or that the Mercury (for example) of Gold or Saturn [lead] would be perfectly of the same Nature with that of Hartshorn;[2] and that the sulphur of Antimony[3] would be but Numerically different from the Distill'd butter[4] or oyle of Roses'[5] (286.4-14).

Eleutherius now makes an interjection whereby he puts it to Carneades that identifying a true set of elements is surely more important than the obtaining of such materials in the pure state. He begins by supposing that his companion met some 'Chymists [Paracelsians]' (286.16) who accepted earth and water as elements, and

[1] Osteacolla is a calcareous deposit forming an incrustation on the roots and stems of plants in sandy ground, especially in some parts of Germany. Formerly called 'glue-bone stone', from its supposed help in the knitting of broken bones.
[2] The derivative which Carneades would expect to obtain from this material would be Spirit of Hartshorn or ammonia.
[3] What Carneades took to be antimony was actually native antimony sulphide or stibnite, which does contain sulphur.
[4] That is, the butter of antimony, or antimony trichloride, which forms a soft, white crystalline mass.
[5] Rose oil is an essential oil extracted from rose petals, and is much used in perfumery.

who ‘being also content to change the Ambiguous Name of Mercury for that more intelligible one of spirit, should consequently make the Principles of Compound Bodies to be Five’ (286.19-24). He asks Carneades whether he considers it ‘something hard [severe] to reject so plausible an Opinion’ (286.25-26), simply because ‘the Five substances into which the Fire divides mixt Bodies are not exactly pure, and Homogeneous’ (286.27-29).

Carneades makes a sensible reply in which he counts it strange that various bodies should be so conveniently decomposed into five distinct decomposition products. He remarks it as rather strange if the opinion just expressed is untrue ‘that it should fall out so luckily’ (287.3-4) that a large ‘Variety of Bodies should be Analyz’d [decomposed] by the Fire into just five Distinct substances’ (287.4-6) may, more or less, ‘Plausibly be call’d Oyle, Spirit, Salt, Water, and Earth’ (287.8-10).

Wishing to avoid a detailed discussion on the subject Carneades says that ‘The Opinion You now propose’ (287.11), being different from the one he ‘was engag’d to examine’ (287.13) he has neither the time nor feels the obligation to treat of it at present. ‘Wherefore [for which]’ (287.16) he will only state the general case, namely that he considers this ‘Opinion in some respects more defensible then [than] that of the Vulgar [common] Chymists’ (287.17-19). Simply by considering the ‘past Discourse’ (287.21), Eleutherius may discover what Carneades thinks of the opinion in question. The reason why this is so is that ‘many of the Objections made against the Vulgar [common] Doctrine of the Chymists seem, without much alteration, employable against this *Hypothesis* also’ (287.22-25). He continues that both doctrines make the same assumption which is difficult to prove ‘that the Fire is the true and Adequate Analyser [decomposer into simpler substances] of Bodies' (287.28-29 – 288.1), and also that all of the different bodies obtainable from a compound material by thermal decomposition 'were so pre-existent in it, that they were but [only] extricated from each other by the *Analysis*' (288.3-5).

Carneades lists four further difficulties with the five-principle system, the main difficulties, he observes, are centred on the objection that not all bodies consist of five principles, and that in any case these are not truly elemental. He first deals with the non-elemental nature of thermal decomposition products, 'this Opinion, too, ascribe[6] to the Productions of the Fire an Elementary simplicity' (288.6-8), which he has demonstrated not to be the case. His second is simply that 'this Doctrine is lyable to some of the other Difficulties, wherewith That of the *Tria Prima* [three principles] is incumber'd [complicated]' (288.9-12).

His third difficulty is that this fixed number of principles would better be applied to most, rather than all, organic materials. He says that 'this quinary [five] number of Elements' (288.13-14) 'ought at least to have been restrain'd to the Generality of Animal and Vegetable Bodies' (288.15-17), for, as already argued by Carneades, 'for ought [aught] has yet been made to appear' (288.19-20) 'consist, either of fewer or more similar substances than precisely Five' (288.20-22). His fourth difficulty is a continuation of the previous one, whereby in minerals 'there is scarce [scarcely] one Concrete [compound material] that has been evinc'd [established] to be adequatly divisible into such five' (288.23-25), and only five 'Principles or Elements' (288.25-26) as held by the theory in question.

[6] Corrected to 'ascribes' in the *Errata*.

He offers an explanation as to why organic substances are easier to separate into five decomposition products than metals and minerals, and this has to do with the density or compactness of the materials under consideration. Organic materials, being of a more open structure than metals and minerals, are easier to decompose into their various fractions through distillation. It is this, Carneades continues, which should help assuage 'your Wonder, that just so many Bodies as five should be found upon the Resolution of Concretes [compound materials]' (289.2-4). Given that heat cannot make 'any such *Analysis* [decomposition] (into five Elements)' (289.5-6) of metals and other minerals, 'whose Texture [structure] is more strong and permanent' (289.7-8), only materials of animal or vegetable origin can yield five fractions on decomposition 'which (probably by reason of their looser Contexture [texture or composition]) are capable of being Distilll'd' (289.11-13).

Carneades makes the point that in organic materials, even if they do not decompose into five different bodies, they do at least separate into five distinct fractions. So that 'whether we suppose that there are, or are not, precisely five Elements, there should ordinarily occurr in the Dissipated [dispersed] parts a five Fold Diversity of Scheme' (289.15-19). He makes a common-sense distinction of materials into three categories, the first of these are the ones which 'remain all fix'd [here: non-volatile] as in Gold, Calcinc'd Talck,[7] &c.' (289.20-21). The second are those which volatilise completely, or 'all ascend, as in the Sublimation [complete volatilisation] of Brimstone [sulphur], Camphire [camphor], &c.' (289.21-23). The third category is those which do partially distill when heated to give a liquid distillate, and an

[7] Talc is a hydrated magnesium silicate, and can be 'calcined' or dehydrated on heating.

undistilled residue in the retort. Materials 'after their Dissipation [dispersal] do associate themselves into new Schemes of Matter' (289.23-25). Most likely the fire will separate these 'into fix'd [here: non-volatile] and Volatile' (289.27), which he qualifies by saying 'in Reference to that degree of heat by which they are distill'd' (289.27-29).

He elaborates on this by adding that the volatile fractions will usually 'ascend either in a dry forme, which Chymists are pleas'd to call, if they be Tastless, Flowers; [8] if Sapid [having taste or flavour], Volatile Salt;[9] or in a Liquid Forme' (290.1-2). The last-named would be those materials which, when heated, yield a liquid distillate.

He continues that the liquor thus produced would itself fall into one of three categories: the first is 'inflamable, and so pass for oyl' (290.6), 'or not inflammable, and yet subtile and pungent, which may be call'd Spirit' (290.7-8), or thirdly, 'strengthless or insipid [tasteless], which may be nam'd Phlegme, or Water' (290.9-10). Likewise the solid portion, or 'the fixt [here: inert] part, or *Caput Mortuum* [inert residue]' (290.11-12), it too is comprised of two distinct portions, and will usually 'consist of Corpuscles, partly Soluble in Water, or Sapid [having taste or flavour]' (290.12-14). He qualifies this by adding '(especially if the Saline parts were not so Volatile, as to fly away before)' (290.14-16). The second portion is 'partly insoluble and insipid [tasteless], which therefore seems to challenge [call in question] the name of Earth' (290.17-19).

[8] An example of this would be sulphur which, when heated, evaporates completely or sublimes, only to condense on the cooler parts of the still in the form of the solid 'flowers of sulphur'.

[9] An example here would be sal ammoniac or ammonium chloride, which sublimes when heated, and the condensed product has a salty, astringent taste.

Carneades argues that although one might readily have known that thermal decomposition would yield the five fractions just named from a compound material, even so it is not necessarily true that those products are elemental bodies pre-existent in the original material and amenable to separation by the fire. He says that although thermal decomposition products from a compound material 'would for the most part be reducible to the five newly [recently] mentioned States of Matter' (290.23-25), it does 'not presently [immediately] follow, that these five Distinct substances were simple and primogeneal [primary] bodies' (290.25-27), and are so 'pre-existent in the Concrete [compound material] that the fire does but [only] take them asunder' (290.27-29).

He then makes the point that the same may be said of various metals and vegetables. He says that 'it does not appear, that all Mixt Bodies, (witness, Gold, Silver, Mercury, &c.)' (291.1-3), and perhaps 'all Vegetables, which may appear by what we said above of *Camphire* [camphor], *Benzoin* [10] &c. are resoluble [resolvable] by Fire into just such differing Schemes [here: methodical lists] of Matter' (291.3-7).

Carneades goes on to list some further points of resemblance between groups of materials which he considers do not qualify them to be counted as elemental. He begins by saying that 'the Experiments formerly alledg'd [cited]' (291.8) will not 'permit us to look upon these separated Substances as Elementary, or uncompounded' (291.8-11). Neither does the fact that such putative elements 'have an Analogy in point of Consistence [solidity or firmness], or either Volatility or Fixtness [here: non-volatility], or else some other obvious Quality, with the suppos'd

[10] A dry and brittle resinous substance, with a fragrant odour, and slightly aromatic taste, obtained from the *Styrax benzoin* tree, used in the preparation of benzoic acid, in medicine, and extensively in perfumes.

Principles, whose names are ascrib'd to them' (291.15-19). And as already stated by Carneades, even if there is a 'Resemblance in some one Quality, there may be such a Disparity in others' (291.21-22), as to justify giving them 'Differing Appellations [names], then [than] the Resemblance is to give them one and the same' (291.23-26).

He goes on to argue that to classify materials by the possession of physical properties in common leads to widely different materials being included in the same group. It would seem 'but [only] a gross [approximate] Way of judging of the Nature of Bodies, to conclude without Scruple [question]' (291.26-29) to classify as having the same 'Nature' (292.1) materials that share 'such General Quality, as Fluidity, Dryness, Volatility, and the like' (292.1-3). He very sensibly reasons that 'each of those Qualities, or States of Matter, may Comprehend [include] a great Variety of Bodies, otherwise of a very differing Nature' (292.3-7), and gives as examples 'the Calxes of Gold,[11] of Vitriol [ferrous sulphate]' (292.7-8), by which he may mean the ferric oxide formed when ferrous sulphate is heated strongly, 'and of Venetian Talck[12] compar'd with common Ashes' (292.7-9). He observes that these materials 'are very dry, and fix'd [inert] by the vehemence of the Fire, as well as they' (292.10-11).

He lists other materials which, although seeming to consist of a single fraction, can be further sub-divided. He has 'formerly Observ'd, touching the Spirit of Box-

[11] Gold does not form an oxide or calx when heated, but Partington mentions the reduction of gold to a powder or calx, by heating gold amalgam, *i.e*. an alloy of gold and mercury.
See: Partington, *History of Chemistry*, 2: 197.

[12] Talc is a hydrated magnesium silicate. Thomson says that this material is found embedded in the serpentine in the mountains of Salzburg and the Tyrol, and was formerly carried to Venice as an article of commerce, being employed in medicine and in cosmetics. Hence the name 'Venetian'.
See: Thomas Thomson, *Outlines of Mineralogy, Geology and Mineral Analysis*, vol.1 (London: Baldwin and Cradock, 1836), 186.

Wood, which though a Volatile, Sapid [having taste or flavour] and not inflamable Liquor' (292.13-16), which is true of this distillate, as it does consist of strongly-scented products dissolved or dispersed in water. He likens this to the 'Spirits of Harts-Horn, of Blood and others' (292.16-17), which would also be strong-smelling, due to the presence of ammonia, and incombustible, as they contain a large proportion of water. He continues that the box-wood distillate has been called 'the Spirit, and esteem'd [considered] for one of the Principles of the wood that affords it' (292.19-21), which spirit, he adds, 'may yet, as I told You,[13] be subdivided into two Liquors, differing from one another,[14] and one of them at least, from the Generality of other Chymical Spirits' (292.21-25). In this latter statement Carneades may be referring to the methanol/acetone fraction, which would be an unusual chemical product, as such a combination of solvents would really be obtained only by distillation of wood.

Carneades invites Eleutherius to 'accommodate [adapt to] to the *Hypothesis* you propos'd' (292.27-28), namely, the one identifying the five divisions of elemental materials given on p. 286, other relevant 'particulars' (292.28-29) drawn from the discussion so far. He explains that it would be 'unseasonable [inopportune] for me to meddle now any further with a Controversie [dispute]' (293.2-3) to which he himself is not a party, but that this gives him the freedom to 'Take my Own time to Declare my self about it' (293.5-7).

For his part Eleutherius, realising that his interlocutor had no inclination to continue with this matter, but 'having perhaps some thoughts of taking hence a Rise' (293.11-

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[13] This is described in detail on pp. 192-196.

[14] The two fractions he probably has in mind are a methanol/acetone one, and another consisting of acetic acid.

12), meaning that at some future time the occasion might present itself 'to make him Discourse [discuss] it more fully' (293.12-13), drops the subject, then offers him another opinion. He tells him that he probably need not 'mind [remind]' (293.17) Carneades 'That both the Patrons [advocates] of the ternary [three] number of Principles' (293.18-19) and those who favour five, attempt to support 'their experiments with a specious [plausible, but in reality fallacious] Reason or two' (293.21-22). He goes on to state why those who believe in the five-element system hold that the salt, water, sulphur or oil, mercury and earth are required in the constituting of physical materials. He begins by acknowledging that those he has 'convers'd with' (293.24-25) he found to be 'Learned men' (293.25-26), and relates their reason for believing in the existence of five elements, as 'otherwise mixt Bodies could not be so compounded and temper'd [brought to a desired quality] as to obtain a due [appropriate] consistence [solidity] and competent [suitable] Duration [permanence]' (293.27-29 – 294.1). He elaborates on this by saying that they believe that salt 'is the *Basis* of Solidity; and Permanency [permanence] in Compound Bodies' (294.2-3), adding cohesion to them, and 'without which the other four Elements might indeed be variously [differently] and loosly blended together, but would remain incompacted [not compacted]' (294.4-7). If salt is to be distributed throughout bodies 'to be compacted by it, and with it' (294.9-10), it requires water 'that [in order that] Salt might be dissolv'd into minute Parts' (294.7-8). He continues 'that [in order that] the mixture may not be too hard and brittle' (294.11-12), it must be made 'more tenacious [tough or cohesive]' (294.14) by means of 'a Sulphureous or Oyly Principle' (294.12-13). Now, a 'Mercurial spirit must be superadded' (294.14-15), or added to what is already present, whose function is to 'premeate [permeate], and as it were leaven' (294.16-17), or imbue with some modifying element, 'the whole Mass, and thereby promote the more exquisite [extreme] mixture and incorporation of the Ingredients' (294.17-20). Finally, he says, some earth is necessary, 'which by its drinesse and poracity[15] may soak up part of that water wherein the Salt was dissolv'd' (294.21-24), 'and eminently [notably] concurr [combine in action]' (294.24) with the other ingredients to give the entire mixture 'the requisite [necessary] consistence' (294.26).

Introducing a note of levity into the discussion, Carneades ventures the opinion: 'as 'twas lately rooted[16] from the Proverb, *that good Wits have bad Memories*, You have that Title [right] as well as a better' (294.28-29 – 295.1-2) to be considered as one of the 'good Wits [men of talent or ability]' (295.3). And Carneades, having thus complimented his companion, now chides him, because he has 'more then [than] once forgot [forgotten]' (295.4) that Carneades has stipulated that they would now 'Examine only the Experiments of my adversaries, not their Speculative Reasons' (295.6-8). That is to say, they would focus their investigation onto the experimental rather than the rational. He concedes that he is indeed willing to examine the argument presented just now by Eleutherius, confident of arriving at a successful conclusion, if time allows.

Carneades 'Subjoynes [adds]' (295.8) that it is not out of 'fear of medling [concerning himself with] with the Argument you have propos'd' (295.9-10) that he will not now consider it, but if they had the time 'you shall have a mind [wish or desire] we may Solemnly [seriously] consider of it together' (295.12-14), and that they will surely 'scarce [scarcely] find it insoluble' (295.15-16). He then makes the

[15] Corrected to 'porosity' in the *Errata*.
[16] Corrected to 'noted' in the *Errata*.

point that the same kind of reasoning may be falsely applied, as it turns out, to other experimental systems. He says 'that such a way of Arguing may, it seems, be speciously [plausibly, but in reality fallaciously] accommodated [adapted] to differing *Hypotheses*' (295.17-19). He gives as example '*Beguinus,*[17] and other Assertors [advocates] of the *Tria Prima* [three principles]' (295.20-21), 'pretend [assert] to make out by such a way, the requisiteness [necessity] of their Salt, Sulphur and Mercury, to constitute mixt Bodies' (295.21-24), whilst ignoring the need for the inclusion of 'Water and Earth' (295.25-26).

He points up another failing in the understanding of material bodies by upholders of both the three and five-element systems. He says that 'neither sort of Chymists seem to have duly consider'd how great Variety there is in the Textures [structures] and Consistences [solidity] of Compound Bodie; sand'[18] (295.27-29 – 296.1) 'and how little the consistence [solidity] and Duration [permanence] of many of them seem to accommodate [adjust to] and be explicable by the propos'd Notion' (296.1-5).

Carneades goes on to relate some experimental evidence in support of the fact that thermal decomposition products are still not elemental but compound bodies, and that even living things produced from water are found to be decomposable by the fire into simpler bodies. He begins by mentioning 'those almost incorruptible Substances' (296.5-6) yielded by thermal decomposition, and which he has 'prov'd to be somewhat compounded, and which the Chymists will readily grant not to be perfectly mixt Bodies' (296.7-10). He invites his companion to recall some experiments whereby Carneades 'shew'd [showed] You that out of common Water

[17] Jean Beguin (1550-1620) French-born medic and chemist, whose *Tyrocinium Chymicum* [Chemistry for Beginners] was published in 1610.
[18] Corrected to 'Bodies; and' in the *Errata*.

only mixt Bodies' (296.13-14), some living ones 'of very differing consistences [solidity]' (296.15-16), and thermally 'resoluble [resolvable]' (296.16) 'into as many Principles as other bodies acknowledg'd to be perfectly [thoroughly] mixt' (296.16-18).

He concludes from this that nature may without any difficulty produce materials having a variety of physical properties and without having to employ a fixed number of elements or principles. He supposes that Eleutherius is not 'Averse [unwilling]' (296.20) to believe 'that Nature by a convenient disposition of the minute parts of a portion of matter may contrive [make up] bodies durable enough' (296.20-23) of more than one 'Consistence [material coherence], without being oblig'd to make use of all' (296.24-25) or 'of any Determinate [fixed] quantity of each of the five Elements, or of the three Principles' (296.26-28) in their production.

He describes the nature of glass as a case in point, noting the simplicity of the starting material employed in its preparation, yet remarking on how their product is a material of almost unique durability. Carneades begins by saying that he has 'Something [to some extent] wonder'd' (297.1) why 'Chymists should not consider, that there is scarce [scarcely]' (297.1-2) any material 'so permanent and indissoluble as Glass' (297.3-4) which they advise may be produced 'of bare [mere] Ashes, brought to fusion by the meer Violence of the Fire' (297.5-7).[19] He then argues that 'since Ashes are granted to consist but [only] of pure Salt and simple Earth, sequestred [separated] from all the other Principles or Elements' (297.7-10), they have to accept that 'Art it self' (297.12) can from two elements or 'one Principle and

[19] What exactly Carneades means is not clear, as common glass is made by heating a mixture of lime, sodium carbonate or potassium carbonate, and sand. Sodium carbonate is produced from the ash (barilla) of certain seashore plants; potassium carbonate is a constituent of wood-ash.

one Element, compound a Body more durable then [than] almost any of the World' (297.13-15). Given that this is true, he challenges his adversaries to prove nature's inability to 'compound Mixt Bodies, and even durable Ones, under all the five Elements or material Principles' (297.17-20), by which he seems to mean within the ambit of the five elements or principles.

Carneades wishes to conclude this part of the discussion, explaining that he has spent enough time on what is a side-issue to the debate in hand. He says that 'to insist [dwell at length on] on this Occasional [incidental] Disquisition [question]' (297.21-22) on the putative existence of five elements, would be to overlook the fact that this particular discussion 'is no part of my first undertaking' (297.26-27), and would have been 'but [only] as a digression, or at best an Excursion' (297.28-29), or a deviation from the direct course of the discussion. Fearing that having 'insisted [dwelt at length on] so long on each of'(298.2-4) 'the four Considerations I propos'd to Discourse [discuss] unto you' (298.2-4) may have caused his companion to 'forget their *Series* [sequence]' (298.6-7), he will repeat them.

Firstly, it is reasonable to doubt 'whether or no' (298.10) fire is 'the genuine and Universal Resolver of mixt Bodies' (298.11-12).

Secondly, it is doubtful whether 'all the Distinct Substances that may be obtain'd' (298.14-15) from a compound material by thermal decomposition, 'were pre-existent there in the formes in which they were separated from it' (298.16-18).

Thirdly, even in accepting the thermal decomposition products of compound materials 'to have been their component Ingredients, yet the Number of such substances does not appear the same in all mixt Bodies; some of them being

Resoluble [resolvable] into more differing substances than three' (298.21-26), others into fewer.

Fourthly, 'those very [exact] substances that are thus separated are not for the most part Pure and Elementary bodies, but [only] new kinds of mixts' (298.28-29 – 299.1-2).

These four considerations prompt Carneades to infer that both the experimental and rational evidence normally adduced by the Paracelsians as proof of their three principles is not convincing, but problematic. He says that as these propositions are valid, he asks to be allowed to infer 'that the Vulgar [common] Experiments' (299.4-5), and 'perchance [perhaps]' (299.5), 'the Arguments [evidence] too wont [accustomed] to be Alledg'd [cited] by Chymists [Paracelsians] to prove, that their three Hypostatical [elemental] Principles do adequately compose all mixt Bodies' (299.6-9), 'are not so demonstrative [making evident]' (299.10) as to cause a 'wary [cautious] Person to acquiesce [accept] in their Doctrine' (299.11-12). He argues that this doctrine will confuse 'considering [thinking] men' (299.14-15) by its 'perplexing darkness' (299.13), and seem to them 'incumbred [entangled] with no small Difficulties' (299.16).

Carneades is irked by the knowledge that a new branch of philosophy can be founded upon so little factual evidence, giving rise to a pompous philosophical school or movement. He begins by saying dismissively that 'from what has been hitherto deduc'd' (299.17-18) we may see what to think of the habit of 'those Chymists' (299.20), finding that 'Diverse [many]' (299.21), though not all, compound materials 'can be resolv'd into, or rather can be brought to afford two or three differing Substances more then [than] the Soot and Ashes' (299.22-25), usually produced by 'the naked fire' (299.26), 'cry up [extol] their own Sect for the Invention of a New Philosophy' (299.27-29). Without pausing for breath Carneades continues 'some of them, as *Helmont*[20] &c. styling themselves Philosophers by the Fire' (299.29 – 300.1), most of them 'ascribing' (300.2) but where possible 'engrossing [attributing exclusively to] to those of their Sect the title of PHILOSOPHERS' (300.3-5).

Lowering the pitch of his delivery, Carneades adopts a tone of haughty indignation, accusing the Paracelsians of considering only the terrestrial sphere in applying their doctrine of their three principles, when the earth itself constitutes a small part only of the wider cosmos. He complains of the narrowness of 'this Philosophy, that reaches but [only] to some of those compound Bodies, which we find but [only] upon, or in the crust or outside of our terrestrial Globe' (300.6-10), which itself is no more than a point in a 'vast extended Universe' (300.11-12), adding mockingly that the *Tria Prima* or three principles give us no 'Account' (300.14) of the wider universe.

Carneades continues in this vein by asking a number of rhetorical questions of the Paracelsian doctrine. He first asks what it teaches us 'either of the Nature of the Sun, which Astronomers affirme to be eightscore and odd times bigger then [than] the whole Earth?'[21] (300.15-18). Secondly, he asks 'or of those numerous fixt Starrs, which, for ought [aught] we know' (300.18-19), most, or all of them, match the Sun in absolute 'bulke and brightness' (300.21). Thirdly he asks, that even if one acknowledges that all compound bodies are composed of the three Paracelsian

[20] Jan Baptista van Helmont (1578/79-1644) Flemish medic and chemist.
[21] *Encyclopaedia Britannica* online (consulted 21-5-2013) gives the size of the Sun as 109 times larger than that of the Earth.

principles, what does such knowledge 'informe us of the Nature of that vast, fluid and Aetherial Substance,[22] that seems to make up the interstellar, and consequently much the greatest part of the World' (300.25-29).

Having raised the question of the presence of the three Paracelsian principles beyond the terrestrial sphere, he now dismisses it as irrelevant, arguing that, whereas Paracelsus himself accepted both his own Salt, Sulphur and Mercury and the four Aristotelian principles of earth, air, fire and water as being constitutive of the wider cosmos, his present-day followers do not profess this doctrine, instead holding that all of the created universe consisted only of their three principles. This being the case, Carneades sees no good reason for his bothering to overturn so unfounded a teaching. He says that Paracelsus believed that both the 'four Peripatetick Elements, but even the Celestial parts of the Universe to consist of his three Principles' (301.3-5). However, as 'the modern Chymists [Paracelsians] themselves have not thought so groundless a conceit [notion or conception] worth their owning, I shall not think it Worth my confuting [proving wrong]' (301.5-9).

Changing his tone again, Carneades reverts to a familiar theme: that of accusing the Paracelsian doctrine of failing to explain natural physical and biological phenomena. He says that he would 'perchance [perhaps] forgive the Hypothesis' (301.10-11) 'if, though it reaches to a very little part of the World, it did at least give us a satisfactory account of those things to which 'tis said to reach' (301.12-15). Instead, even concerning compound materials it gives 'very imperfect information' (301.17). He goes on to ask how the three Paracelsian principles 'discover [reveal] to us the

[22] This is a reference to the Aristotelian doctrine of the ether or fifth element, which was conceived of as the element filling all space beyond the sphere of the moon, as the constituent substance of all the stars and planets, and of their spheres.

Reason, why the Loadstone drawes a Needle and disposes it to respect the Poles, and yet seldom precisely points at them?'[23] (301.19-23). He next asks how Paracelsus' hypothesis can 'teach Us how a Chick is formed in the Egge, or how the Seminal Principles of Mint, Pompions [pumpkins], and other Vegetables' (301.24-27) already mentioned, can change water 'into Various Plants, each of them endow'd with its peculiar and determinate shape, and with divers [many] specifick and discriminating [distinguishing] Qualities' (301.28-29 – 302.1-2).

Carneades than asks 'How does this Hypothesis shew [show] us' (302.3) how much salt, sulphur and mercury is required 'to make a Chick or a Pompion (pumpkin]' (302.5-6). Even if this is known, then 'what Principle is it, that manages these Ingredients, and contrives [designs]' (302.7-8) such things as 'the White and Yelk [yolk] of an Egge into such a variety of textures [structures or constitution] as is requisite [appropriate] to fashion' (302.9-11) the various parts 'of a Chick' (302.14). And not just to make limbs 'but to connect them altogether [into a whole], after the manner that is most congruous [suitable] to the perfection of the Animal' (302.15-18) in question.

Reiterating his question as to the nature and composition of the organising principle responsible for the production of living things, he posits that even if this principle is produced from the three Paracelsian principles, then some agent external to these must organise its production. He argues that 'to say, some more fine and subtile [minute] part of either or all the Hypostatical [elemental] Principal is the Director in

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[23] Loadstone or lodestone is a variety of magnetite, a black magnetic form of iron oxide, and due to its strongly magnetic nature forms natural magnets.
Since at least the 15th century the variation between the magnetic and geographic north has been noted, which difference is referred to here by Carneades.

all this business, and the Architect of all this Elaborate structure' (302.19-23), allows the 'occasion [opportunity] to demand again, what proportion and way of mixture of the *Tria Prima* [three principles] afforded [provided] this *Architectonick*[24] Spirit, and what Agent made so skilful and happy [fortuitous] a mixture?' (302.23-28).

Faced with this problem, what do the Paracelsians propose as its solution? If they 'keep themselves within their three Principles' (302.29 – 303.1) they will be stating that the agent that organises the *tria prima* or three principles is itself constituted of the *tria prima*, which is as much as saying that matter organises itself. They will, he says, 'be lyable to the same Inconvenience that the Answer to the former was' (303.1-3).

Not only this, but the three Paracelsian principles fail to account for the physical properties of natural, mainly inorganic bodies. Carneades will not now 'prosecute [deal with in detail] the Imperfections of the Vulgar Chymists Philosophy' (303.6-7) as it would 'intrench [encroach] upon the Theame [theme] of a Friend of ours here present' (303.4-5), obviously a reference to Boyle himself, present as a mute note-taker. Nonetheless, he lists some things which the Paracelsians would have difficulty in explaining 'by their three Principles' (303.9), beginning with the 'abstruse [difficult to understand] Properties of mixt Bodies' (303.10). Then there are 'such Obvious and more familiar *Phaenomena* as *Fluidity* and *Firmness*, The Colours and Figures [shapes generally] of Stones, Minerals and other compound Bodies' (303.11-14), and finally, 'The Nutrition of either Plants or Animals, the

[24] Having the function of superintendence and control, *i.e.* having the relation that an architect bears to the artificers employed on the building.

Gravity [here: density] of Gold or Quicksilver [mercury] compar'd with Wine or Spirit of Wine [alcohol]' (303.14-17).

Making a final comment on the matter, Carneades remarks on the near impossibility of giving a rational account of the composition of natural materials from any possible combination of the three Paracelsian principles, and that any such account would more likely damage the reputation of its upholders than enlighten the sensible. He states that any attempt 'to render a reason [account] of' (303.18) the above examples, among others, 'from any proportion of the three simple Ingredients, Chymists will be much more likely to discredit themselves and their *Hypothesis*, then [than] satisfy an intelligent Inquirer after Truth' (303.20-25).

Eleutherius interrupts with a plausible interjection, namely that his companion's objection could legitimately be levelled against any system positing a fixed number of elements. He argues that 'This Objection' (303.26-27) can be made against not only 'the four Peripatetick [Aristotelian] Elements [earth, air, fire and water]' (303.28), but against almost every '*Hypothesis*, that pretends [claims] by any Determinate [fixed] Number of Material Ingredients to render a reason [account] of the *Phaenomena* of Nature' (303.29 – 304.1-4). He goes on to cite an argument postulated by Sennert whereby the properties of compound materials may be derived from the three Paracelsian principles, though not from the Aristotelian elements. He says that the 'great Champion' (304.7) of the Paracelsian principles 'The Learned *Sennertus*[25] assignes this noble [elevated] use of the *Tria Prima* [three principles], That from Them, as the neerest and most Proper [correct] Principles, may be Deduc'd and Demonstrated the Properties which are in Mixt Bodies, and which

[25] Daniel Sennert (1572-1637) German-born professor of medicine at Wittemberg. He accepted Paracelsus' three principles, but rejected some other parts of the Paracelsian doctrines.

cannot be Proximately [immediately]' (304.7-13), 'deduc'd from the Elements [earth, air, fire and water]' (304.14-15). He continues that Sennert holds that this is most obvious in the investigation of 'the Properties and Faculties of Medicines' (304.16-18).

He pays his companion the compliment of saying that his fair-mindedness will cause him to accept the contribution to philosophy attributable to the beliefs and experimental findings of the Paracelsians. Eleutherius is sure 'That the Person You have assum'd [adopted or put on], of an Opponent of the *Hermetick Doctrine*,[26] will not so far prevaile [succeed] against your Native [innate] and wonted [customary] Equity [fairness], and so keep You from acknowledging that Philosophy is much beholden [obliged] to the Notions [concepts or ideas] and Discoveries of Chymists [Paracelsians]' (304.19-26).

Carneades replies by making an attack on the pomposity of his adversaries. He berates the 'Chymists' (304.27) for their lack of modesty, saying that if they had proposed 'their Opinion of the *Tria prima* [three principles], but [only] as a Notion [concept] useful among Others, to increase Humane knowledge, they had [would have] deserv'd more of our thanks' (304.29 – 305.1-4), than our disagreement. However, since what 'they pretend [claim]' (305.5-6) has less to do with a doctrine intended to advance philosophy than to 'make this Notion [concept] ([27]attended by a few lesse considerable ones) pass for a New Philosophy it self' (305.8-10). But no,

[26] Hermes, in Latin Mercurius, is the messenger of the gods. The metal and spirit mercury are vital to Alchemy. Hermeticism is the outlook associated with the Hermetic writings, a literature in Greek which developed in the early centuries of the Christian era under the name Hermes Trismegistus [Hermes the Thrice Great God], much of it associated with Astrology, Alchemy, and other occult sciences, and there is also a Hermetic Literature.
[27] Opening bracket added in the *Errata*.

they persist with their 'phancie [fancy]' (305.11) *i.e.* imagining their doctrine to be true 'that the famous *Quercetanus*[28] scruples [doubts] not to write, that if his most certain Doctrine of the three Principles were sufficiently Learned, Examin'd and Cultivated, it would easily Dispel all the Darkness that benights [clouds] our minds' (305.12-17) and clarify all difficulties.

In a mocking tone Carneades continues that 'This School affording [providing] Theorems and Axiomes irrefragable [incontestable]' (305.19-21) to be accepted wholesale by 'impartial Judges; and so useful withal [in addition]' (305.22-23) to save us from 'having recourse [resorting to], for want [lack] of the knowledg[29] of causes[30] to that Sanctuary of the igorant,[31] Occult [secret, mysterious] Qualities' (305.24-26).

Carneades rails that as 'this Domestick [familiar] Notion [concept] of the Chymists [Paracelsians] is so much overvalued by them' (305.27-28) he thinks it appropriate for them to be 'made sensible of their mistakes' (305.29 – 306.1) *i.e.* their mistakes should be made evident to them. They should 'be admonish'd [advised] to take in more fruitful and comprehensive Principles, if they mean to give us an account of the *Phaenomena* of Nature' (306.1-5). They should not, he continues 'confine themselves' (306.5), and indeed others, 'to such narrow Principles' (306.6-7) as this will 'scarce [scarcely] inable them' (306.8) to give an 'intelligible' (306.9) account

[28] Joseph du Chesne (Quercetanus) (1521/44-1609) French-born physician-in-ordinary to King Henry IV, and follower of Paracelsus.
[29] Corrected to 'knowledge' in the 1680 edition.
[30] A reference to the four causes of Aristotle: the *efficient cause*, the force, instrument or agency by which a thing is produced; the *formal cause*, the form or essence of the thing caused; the *material cause*, the elements or matter from which it is produced; the *final cause*, the purpose or end for which it is produced.
[31] Correct to 'ignorant' in the 1680 edition.

of one tenth of 'all the *Phaenomena* of Nature' (306.10-11). He adds as an afterthought, 'but [if not] even of all such as by the *Leucippian* [32] or some of the other sorts of Principles may be plausibly enough explicated' (306.11-14). And here he may have in mind Boyle's own scheme of matter and motion as the fundamental principles of the created universe.

He extends the scope of his objections beyond the teaching he is now considering to encompass other doctrines, arguing that a single truth may have the capacity to prove more than one theory false. He says that although he accepts 'that the incompetency [inadequacy] I impute [lay to the charge of] the Chymical *Hypothesis* is but [only] the same which may be Objected against that of the four Elements, and divers [several] other Doctrines' (306.15-19), held by the educated. However, as he is now investigating only 'the Chymical *Hypothesis*' (306.21) he feels justified, 'if what I impute [lay to the charge of] to it be a real inconvenience, either it should cease to be so, or I should scruple [doubt] to object it' (306.22-25). That is to say he should doubt to bring it as a charge against his adversaries, 'because other Theories are lyable thereunto [unto that same charge], as well as [to the same extent as] the Hermetical' (306.25-27). He rounds off this line of thinking by observing that he cannot understand 'why a Truth should be thought lesse a Truth' (306.27-28) for having the capacity to refute more than one doctrine.

Carneades is relieved at the favourable reception accorded to the fair-mindedness of what he has just said, hoping that his companion has no ulterior motive in so doing, then goes on to praise his adversaries for their contribution to practical chemistry.

[32] Leucippus was a 5th century BCE, Greek philosopher. He is traditionally regarded as the founder of atomism in Ancient Greek philosophy. This theory was elaborated on by his follower Democritus.

He states that he is 'oblig'd' (307.1) for the 'favourable Opinion' (307.2-3), 'if there be no design [cunning scheme or stratagem] in it' (307.4). He adds that he requires neither 'an Artifice [making by art or skill]' (307.5) nor 'a Complement' (307.6), 'to acknowledge the great service that the Labours of Chymists have done the Lovers of useful Learning' (307.6-9), even allowing for 'their Arrogance' (307.10).

Recalling the subject-matter under discussion, he says that 'we are as well [to the same extent] examining to[33] the truth of their Doctrine as the merit of their industry' (307.11-13) he must, 'in order to [for the sake of]' (307.13-14) the primary subject of discussion, continue 'to talk at the rate [pace] of the part I have assum'd [adopted]' (307.15-16). He goes on to qualify his opinion on the contribution of his adversaries by remarking that 'when I acknowledg[34] the usefulness of the Labours of *Spagyrists* [Paracelsians] to Natural Philosophy [here: science]' (307.16-19), it was on account of 'their experiments' (307.19-20) rather than 'Their Speculations' (307.20-21), adding that 'it seems to me, that their Writings, as their Furnaces, afford as well [to the same extent] smoke as light; and do little lesse obscure some subjects, then [than] they illustrate others' (307.21-25).

Carneades now makes a clever argument in which he posits that mastering a particular body of knowledge may be a pre-requisite to acquiring a given skill, yet being in possession of such a body of knowledge is insufficient to confer on its holder the title of legitimate practitioner of the skill in question. He avers that if a man is 'to be an Accomplisht Naturalist [natural philosopher or scientist]' (307.26-27) then he must not be 'a stranger to Chymistry' (307.27-28). Yet for him,

[33] This 'to' removed in the *Errata*.
[34] Corrected to 'acknowledge' in the 1680 edition.

knowledge of practical chemistry is almost as the ‘Letters of the Alphabet, without whose knowledge ’tis very hard for a man to become a Philosopher; and yet that knowledge is very far from being sufficient to make him One’ (308.1-6).

Reverting to his more sober demeanour, Carneades pays an oblique compliment to the doctrine of the three principles, saying that its adoption by some practitioners of chemistry served to displace the revered Aristotelian doctrine of the four elements. However, irrespective of this, the Paracelsian teaching still retains its shortcomings in Carneades’ eyes. He says that in further considering ‘what you alledg[35] in favour of the Chymical Doctrine of the *Tria Prima* [three principles]’ (308.9-11) has its usefulness, ‘and what the Divisers[36] and Embracers of it’ (308.12-13) have furthered knowledge ‘by helping to destroy that excessive esteem [favourable opinion] or rather veneration, wherewith [with which] the Doctrine of the four Elements was almost as generally as undeservedly entertain’d [admitted to consideration]’ (308.15-19).

Carneades introduces the argument favoured by Sennert, and in the latter’s opinion, the finest philosophers, which is employed to prove the existence of the three Paracelsian principles in compound materials, but which fails to convince Carneades. He bluntly states that ‘the very way of Probation [investigation]’ (308.23-24) employed by the ‘more Learned’ (308.24) and ‘more Sober [moderate]’ (308.25) proponents of the Paracelsian system to ‘evince [establish] the Chymical Principles in Mixt Bodies’ (308.26-27), is not at all ‘convincing’ (308.28) to him. ‘*Sennertus*[37]

[35] Not corrected either in the *Errata* or in the 1680 edition.
[36] Corrected to ‘devisers’ in the *Errata*.
[37] Daniel Sennert (1572-1637) German-born professor of medicine at Wittemberg. He accepted Paracelsus’ doctrine of the three principles, but rejected other parts of his teaching.

Himself' (309.1) 'layes Great weight' (309.1-2) upon 'This grand and leading Argument' (308.29), and holds that 'the most Learned Philosophers employ this way of Reasoning to prove the most important things, proposes thus' (309.2-5). This passage may be translated as:

> 'Wherever (sayes he) the same affections and qualities are involved in many things it is necessary that a certain common principle exist, in the same way that all things are heavy on account of earth, hot on account of fire. Yet colours, odours, tastes, to be burnt, and the like, belong to minerals, metals, gems, stones, plants and animals. Therefore they exist thanks to, and are subject to, some common principle. But because of such a principle they are not elements. For they lack the capacity of such productive qualities. Therefore from where other principles may flow should be inquired into.' (309.5-18).[38]

Carneades explains that he quotes this passage in the original language so that he 'might also retain the propriety [distinctive quality] of some Latine Termes' (309.22-24), as these do not easily translate into English. As for the arguments presented in this passage, Carneades is dismissive: they are, he opines 'built upon a precarious supposition, that seems to me neither Demonstrable nor true' (309.27-29).

What Carneades cannot accept about this passage is the notion that some one property found in a variety of materials is conferred on them all through their participation in some common quality. His reason for rejecting this notion is that the

[38] '*Ubicunque* (sayes he) *pluribus eaedem affectiones & qualitates insunt, per commune quoddam Principium insint necesse est, sicut omnia sunt Gravia propter terram, , calida propter Ignem. At Colores, Odores, Sapores, esse φλογιστόν, & similia alia, mineralibus, Metallis, Gemmis, Lapidibus, Plantis, Animalibus insunt. Ergo per commune aliquod principium, & subiectum, insunt. At tale principium non sunt Elementa. Nullam enim habent ad tales qualitatates producendas potentiam. Ergo alia principia, unde fluant, inquirenda sunt*.'

presence of the common quality in question, as it is in itself a quantifiable physical attribute, may simply be incapable of accounting for the measurable properties of the material in which it is supposedly present. He questions how it can 'appear that where the same quality is to be met with in many Bodies, it must belong to them upon the Account of some one Body whereof [of which] they all partake' (310.1-5).

That the passage quoted specifies physical materials is asserted by Carneades when he says that 'the Major of our Authors Argument' (310.5-6) is referring to matter is obvious 'by the Instances of Earth and Fire he annexes [adds] to explain it' (310.8-9). His first particular example asks 'how can he prove, that the Gravity [weight] of all bodies proceeds from what they participate of the Element of Earth?' (310.11-14). He avers that both ordinary and 'the more pure Distill'd Rain Water is heavy, and Quicksilver [mercury] is much heavier than Earth it self' (310.16-18). He then makes the observation that none of his 'Adversaries has yet prov'd, that it contains any of that Element' (310.19-21).

Having given short shrift to the Paracelsian explanation of properties or attributes of various materials as occurring through a mutual participation in qualities common to all such materials, he is no less dismissive of the Aristotelian explanation, stating peremptorily that he 'the Rather [the more readily] make use of this Example of Quicksilver [mercury], because I see not how the Assertors [advocates] of the Elements will give any better Account of it then [than] the Chymists' (310.21-25). Again the same kind of reasoning is applied as before, only now the element which is supposedly common to the various materials is water. When one asks how a physical material 'comes to be a Fluid' (310.26), the Aristotelians 'will answer, that it participates much of the Nature of Water' (310.27-28). They may even assert that of the earth, air, fire and water which subsist as an admixture in all materials that water may be the principle element of a body, even if it is not present in a sufficiently large proportion to cause the body to exist as a fluid. He points out that for the Aristotelians, water may be 'the Predominant Element' (311.1) in a fluid, even though many materials 'which by Distillation afford Liquors that weigh more then [than] their *Caput Mortuum* [inert residue] do not yet consist of Liquor enough to be Fluid' (311.3-6).

He now asks the Aristotelians how they account for the density of mercury which is much greater than that of any of the four elements from which it is supposedly composed. Carneades is well aware of the much greater density of mercury than water, a difference of approximately 13.5 to 1, so when he puts it to the Aristotelians to explain the great weight or density of mercury ''tis reply'd, that 'tis by reason of the Earth that abounds in it' (311.8-9). He objects that on their account of materials it must also contain some air and fire 'which they affirm to be light Elements' (311.11-12). He then poses the question of them 'how comes it that it should be so much heavier then [than] Earth of the same bulk, though to fill up the porosities and other Cavities it be made up into a mass or paste with Water, which it self they allow [acknowledge] to be a heavy Element' (311.12-18).

He goes on to discuss how a variety of materials compare in density, following some physical or thermal processing. Reverting to 'our *spagyrists* [Paracelsians], we see that Chymical Oyles and fixt Salts, though never [ever] so exquisitely [carefully] purify'd and freed from terrestrial parts, do yet remain ponderous [heavy] enough'

(311.19-23). What Carneades seems to be arguing here is that irrespective of the efforts made to free some materials from solid impurities, such materials may still remain quite dense. By contrast, the ashes yielded in the burning of the densest woods are produced in lower amounts than those yielded from much lighter vegetables. Quoting from his own experimental evidence, he notes that a given quantity ‘of some of the heaviest Woods, as *Guajacum*[39] that will sink in Water’ (311.24-26), and when burnt reduces to a ‘much less weight of them (whereof [of which] I found but [only] a small part to be Alcalyzate)[40] then [than] much lighter Vegetables’ (311.27-29 – 312.1).

Carneades continues that, unlike the wood itself, the charcoal of guaiacum floats on water. He cites this behaviour as evidence that ‘the Differing Gravity [density] of Bodies proceeds chiefly from their particular Texture [constitution or structure]’ (312.4-5). This fact is well illustrated by gold ‘the closest and Compactest of Bodies’ (312.6-7) which has a density much higher than ‘any parcell of Earth’[41] (312.9). Perhaps wishing to avoid a discussion of the weight of the matter from which the heavenly bodies are composed, he says that he will not examine the possible arguments ‘touching the Gravity [weight] or Quality Analagous thereunto [in addition to that], of even Celestial bodies, from the motion of the spots about the Sun, d[42] from the appearing equality of the suppos’d Seas in the Moon’[43] (312.14-

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[39] The hard and heavy, brownish-green wood of *Guaiacum Officinale* and *Guaiacum Sanctum*, which, with a density of up to approximately 1.3 times that of water, does sink in water.
[40] He probably means producing a smaller amount of potassium carbonate or potash than expected.
[41] Gold is indeed a very heavy metal, with a density 19.3 times that of water.
[42] Corrected to ‘and’ in the *Errata*.
[43] It might be helpful to bear in mind that Boyle was writing before Newton’s explanation of what is now called ‘gravity’ was published in his ‘*Principia*’ of 1687.
Accounts of sunspots and lunar features were published in Galileo’s *Sidereus Nuncius* [Starry Messenger] of 1610.

16), nor will he 'consider how little those *Phaemonea*[44] would agree with what *Sennertus* presumes concerning Gravity [weight]' (312.19-18). Having raised the subject of Sennert he continues 'But further to invalidate his supposition, I shall demand, upon what Chymical Principle Fluidity depends' (312.18-21).

He asserts that fluidity is one of 'the most diffused quality of the universe, and far more General then [than]' (312.23-24) the majority of those present 'in any of the Chymical Principles [salt, sulphur and mercury] or *Aristotelian* Elements [earth, air, fire and water]' (312.26-27). Considering the Earth as an inconsequential solid point, Carneades surmises, by comparison, that both the air and 'that vast expansion we call Heaven' (312.28-29), 'and perhaps to[45] the Sun and the fixt Stars are fluid bodies' (313.2-4). He next demands 'from which of the Chymical Principles Motion flowes; which yet is an affection of matter much more General then [than] any that can be deduc'd from any of the three Chymical Principles' (313.4-9). What remains implicit, though left unstated, in Carneades' questions are Boyle's twin principles of matter and motion which avoid this difficulty, as he posits that both principles were produced through divine agency at creation.

He now goes on to consider the origin of light and sound, and queries how they might be derived from the three Paracelsian principles. He asks how these might produce 'Light, which is not only to be found in the Kindl'd [ignited] Sulphur of mixt Bodis'[46] (313.10-12), in the tails of 'Glow-wormes, and in the Vast bodies of the Sun and Stars' (313.15-17), but also in 'those sorts of rotten Woods, and rotten

[44] Corrected to '*Phaenomena*' in the 1680 edition.
[45] Corrected to 'too' in the *Errata*.
[46] Corrected to 'Bodies' in the 1680 edition.

Fish that shine in the Dark'[47] (313.13-14). He expresses his interest in knowing 'in which of the three Principles the Quality, we call Sound, resides as in its proper Subject' (313.17-20), making the common-sense observation that a quantity of 'either Oyl falling upon Oyle' (313.20-21), or likewise spirit or salt, will 'create a sound' (313.24-25).

Carneades increases the scope of his questioning to include the Aristotelians by including 'water upon water, and Earth upon Earth' (313.26-27). He could continue with a list of 'other qualities to be met within divers [many] bodies' (313.28-29) to which he adds wryly his belief that his adversaries 'will not in haste assign any Subject' (314.1-2), and explains 'upon whose account it must needs be, that the quality belongs to all the other several bodies' (314.2-4). He seems to mean that there are qualities to be found in all manner of materials, including the putative elements. Yet the origin of such qualities cannot be the bodies in which they are already present.

He widens the discussion further still to include some other beliefs held by his adversaries. He will 'compare the supposition we are examining, with some other of the Chymical Tenents [tenets or doctrines]' (314.6-8). Firstly, he cites the doctrine 'that more then [than] one quality may belong to, and be deduc'd from one Principle' (314.9-11). He gives as examples their ascribing 'to Salt Tasts, and the power of Coagulation; to sulphur, as well [to the same extent] Odours as inflamableness; And

[47] What Carneades is referring to is the phenomenon of bioluminescence – the production of light by living organisms, such as certain fungi on rotting wood, certain bacteria on decaying meat or fish, and in the bodies of some creatures.

some of them ascribe to Mercury, Colours' as all of them do effumability'[48] (314.12-13).

Secondly, he gives the example of volatility which he says obviously 'belongs in common to all the three Principles, and to Water too' (314.18-20). He goes on to say that ''tis manifest [obvious], that Chymical Oyles are Volatile' (314.20-21). He argues that 'divers [several] Salts Emerging, upon the Analysis [decomposition] of many Concretes [compound materials], are very Volatile' (314.22-24). This fact 'is plain from the figitiveness[49] of Salt,[50] of Harts-horne, flesh, &c. ascending in the Distillation of those bodies' (314.24-26).

Continuing with his discussion of volatility, Carneades remarks that almost everyone has seen 'How easily water may be made to ascend in Vapours' (314.27-29). He goes on to note that Paracelsus referred to the volatility of liquids as resulting from the presence in them of a mercurial principle. That he is still discussing the volatility of water is inferred from his saying that 'as for what they call the Mercurial Principle of bodies, that is so apt [likely] to be rais'd in the form of Steam' (314.29 – 315.1-3), which principle is defined by Paracelsus and others 'by that aptness [habitual likelihood] to fly up' (315.4-5).

He draws the inference from the foregoing that it appears 'that Chymists' (315.6-7) have not 'been accurate in their Doctrine of qualities, and their respective Principles' (315.7-9), the reason being that 'they both derive several qualities from the same

[48] The OED online (consulted 03-07-2013) gives this as an obsolete nonce-word, and attributes it to Boyle. It means 'capability of being converted into vapour'.
[49] Corrected to 'fugitiveness' in the *Errata*.
[50] Although it has not been changed in either the *Errata* or the 1680 edition, this comma may be unintended. 'Salt of Harts-horne', meaning ammonium carbonate, would make better sense here.

Principle, and must ascribe the same quality to almost all their Principles and other bodies besides' (315.9-13). Carneades goes on to say that this is simply accepted 'without sufficient proof, by your *Sennertus*'[51] (315.14-15), clearly dissatisfied by the latter's lack of rigour in his consideration of the distinction between qualities and principles.

Carneades next cites another argument by which four Aristotelian elements are posited to constitute not just all compound materials, but that Paracelsian principles are themselves composed of the Aristotelian elements. He says that 'upon the Bye [in passing]' (315.16) the foregoing may help in appraising the style 'of Argumentation [process of reasoning], which that fierce Champion of the *Aristotelians* against the Chymists [Paracelsians], *Antonius Guntherus Billichius*[52] employs' (315.18-21). Carneades reports that 'he pretends [asserts] to prove against *Beguinus*,[53] that not only the four Elements [earth, air, fire, water] do immediately [directly] concur [combine in action] to Constitute every mixt body, and are both present in it, and obtainable from it upon its Dissolution' (315.21-26), but, in addition, 'in the *Tria Prima* [three principles] themselves, whereinto [into which] Chymists [Paracelsians] are wont [accustomed] to resolve mixt Bodies, each of them clearly discovers [reveals] it self to consist of four Elements' (315.27-29 – 316.1). He notes that he finds this 'Ratiocination [a conclusion arrived at by reasoning]' (316.2) 'somewhat unusual' (316.3). He 'did the other Day Transcribe it' (316.3-4) and it may be translated as follows:

[51] Daniel Sennert (1572-1637) German-born medic and chemist, professor of medicine at Wittemberg. Influenced in his thinking by both Paracelsus and Aristotle.
[52] Anton Guenther Billichius, active *c*. 1600, medic and chemist.
[53] Jean Beguin (1550-1620) French-born medic and chemist whose *Tyrocinium Chymicum* [Chemistry for Beginners] was published in 1610.

'We begin, with Beguin, with green wood, which if burnt up completely you will see in the exuded moisture, water, in the smoke air, fire in glowing coals and flame, earth in ashes: which if Beguin had wished could have collected from it an aqueous fraction, with an oily fraction left behind, and to extract a salt from the ashes. I will demonstrate before your very eyes each one of the four elements individually, with the same skill by which I demonstrated them in green wood. The aqueous fluid I will move to the fire. One will see for oneself water boiling, will see air in the vapour, will hear fire in the seething liquor, more of what is not quite earth one will see in the fraction which settles out. Furthermore the oily humour, in itself humid and fluid water, once ignited certainly in flame produces fire, in smoke air, earth in strong-smelling soot and oily lees. Finally salt, Beguin himself calls dry and terrestrial, which having been produced, nevertheless cannot be concealed by either water or caustic power. Indeed when it has been turned by the violence of the fire into vapour neither can it be shown to be different from air. The same for milk, eggs, flax seeds, cloves, soda and sea-salt. Finally concerning antimony, which opinion has, came from green wood; the same about the parts of those things of which Beguin draws the opinion that from the aqueous humour of green wood comes the same oily liquor which came from salt' (316.6 – 317.6).[54]

[54] ' *Ordiamur, cum Beguino, a ligno viridi, quod si concremetur, videbis in sudore Aquam, in fumo Aerem, in flamma & Prunis Ignem, Terram in cineribus : Quod si Beguino placuerit ex eo colligere humidum aquosum, cohibere humidum oleaginosum, extrahere ex cineribus salem ; Ego ipsi in unoquoque horum seorsim quatuor Elementa ad oculum demonstrabo, eodem artificio quo in lingo viridi ea demonstravi. Humorem aquosum admovebo Igni. Ipse Aquam Ebullire videbit, in Vapore Aerem conspiciet, Ignem sentiet in aestu, plus minus Terrae in sedimento apparebit. Humor porro Oleaginosus aquam humiditate & fluiditate per se, accensus vero Ignem flamma prodit, fumo Aerem, fuligine, nidore & amurca terram. Salem denique ipse Beguinis siccum vocat & Terrestrem, qui tamen nec fusus Aquam, nec caustica vi ignem celare potest ; ignis vero Violentia in halitus versus nec ab Aere se alienum esse demonstrat ; Idem de Lacte, de Ovis, de semine Lini, de Garyophyllis, de Nitro, de sale Marino, denique de Antimonio, quod fait* [corrected to *fuit* in the 1680 Edition] *de*

Somewhat impatiently, Carneades says that 'this bold Discourse [account]' (317.7) would not be 'very difficult to confute [prove to be wrong]' (317.9), but the time available for the 'more necessary Part of my Discourse [account]' (317.12-13) is as short as Guntherus's account is 'considerable' (317.10). He refers to their earlier discussion on the decomposition products from the burning of wood, then goes on to pass judgement on Guntherus's account of the same experiment. He says 'wherefore [on account of which]' (317.13) referring Eleutherius to what he has said to '*Themistius* on the like occasion' (317.17) regarding the 'Dissipated [dispersed] Parts of a burnt piece of green Wood' (317.15-16), given on pp. 26-27, and now goes on to consider how 'sleightly [lightly] and superficially our *Guntherus* talks of the dividing of the flame of Green Wood into his four Elements' (317.18-21).

Firstly, 'When he makes that vapour to be air' (317.21-22), although when condensed, 'presently [immediately] discovers [reveals] itself to have been but [only] an Aggregate of innumerable very minute drops of Liquor' (317.23-26). That is to say, what would now be classed as an aerosol, such as if formed by mist, fog or smoke dispersed in air. Secondly, he is equally dismissive of Guntherus when he complains that he 'would prove the Phlegmes [here: the aqueous fraction] being compos'd of [constituted of] Fire by that Heat which is adventitious [extraneous] to the Liquor, and ceases upon the absence of what produc'd it' (317.26-29 – 319 [318].1).[55] He adds by way of elaboration, regardless of whether the agency at work is 'an Agitation proceeding from the motion of the External Fire, or the presence of a

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Ligno viridi Judicium ; eadem de illorum partibus, quas Beguinus *adducit, sententia, quae de viridis ligni humore aquoso, quae de liquore ejusdem oleoso, quae de sale fuit.*'

[55] The order of pages 317 and 318 is reversed, and pages 318 and 319 are incorrectly numbered, in the 1661 edition.

Multitude of igneous [fiery] Atomes' (319 [318].1-4) 'pervading the pores of the Vessel' (319 [318].4-5), that is to say, passing through the vessel from the outside, and rapidly spreading through or 'nimbly permeating the whole Body of the Water' (319 [318].5-6).

Rather than make much of 'these and divers [several] other Weaknesses' (319 [318].7-8) he would prefer to 'take Notice [take heed] of what is more pertinent to the Occasion [circumstance] of this Digression' (319 [318].9-11), which is of Guntherus 'Taking it for Granted, that Fluidity (with which he unwarily seems to confound Humidity)' (319 [318].11-13), as one might expect him to, if as he believes, the latter 'must proceed from the Element of Water' (319 [318].13-14). This association is at least a logical one, but what Carneades cannot accept is when 'he makes a Chymical Oyle to Consist' (319 [318].14-15) of water, 'and yet in the very next Words proves, that it consists also of Fire, by its Inflamability' (319 [318].16-18).

Carneades cites as an example highly purified alcohol, whose behaviour when ignited he accuses Guntherus of 'not remembering' (319 [318].18-19). He relates 'that exquisitely [extremely] pure Spirit of Wine [alcohol] is both more Fluid then [than] Water it self' (319 [318].19-21), and yet will be completely consumed by fire, 'without leaving the Least Aqueous Moisture behind it' (319 [318].22-23). Neither is there any earthly residue, as the burnt alcohol does not deposit 'such an *Amurca* [here: oily residue] and Soot as he would Deduce the presence of Earth from' (319 [318].23-25). Carneades states that from the above example it may be concluded from Guntherus's doctrine that alcohol consists both of water and fire, its 'great

Fluidity' (319 [318].27-28) indicating water, and 'its burning all away to be all disguised Fire' (319 [318].29 – 318 [319].1).

Carneades is no better disposed towards him when he remarks on 'the like [similar] way of Probation [investigation] our Author would shew [show] that the fixt salt of Wood [potassium carbonate or potash] is compounded of the four Elements [earth, air, fire and water]' (318 [319].1-4). He criticises Guntherus's reasoning, as the latter's understanding on the matter is that 'being turn'd by the violence of the Fire into steames, it shews [shows] it self to be of kin [related in qualities] to Air' (318 [319].4-7). What he means by this assertion rightly puzzles Carneades, as potassium carbonate or potash, if this is what he is speaking of, is a constituent of wood ash, and as such is an inert, heat resisting material, and does not turn into steam or vapour on heating. Calling in question Guntherus's knowledge of practical experiment, Carneades doubts 'whether he ever saw a true fixt Salt (which to become so, must have already endur'd the violence of an Incinerating Fire) brought by the Fire alone to ascend in the Form of Exhalations [vapours]' (318 [319].7-12). He grants that if Guntherus had actually seen such a salt, and had 'caught those Exhalations in convenient Vessels' (318 [319].13-14), meaning if he had condensed whatever vapours had been released, 'he would have found them as well as [in addition to] the Steames of common Salt, &c. of a Saline and not an Aereal [airlike] Nature' (318 [319].14-17).

He goes on to correct Guntherus's explanation of melting, arguing that when materials melt it is not due to an inherent aqueous component at play, but rather due to the action of heat on the micro-particles of the material. He says that Guntherus 'takes it also for Granted, that the Fusibility [melting] of Salt must be Deduc'd from Water' (318 [319].18-20), but instead it is 'so much the Effect of heat variously agitating the Minute Parts of a Body, without regard to Water' (318 [319].20-23). What Carneades is implying, but is not stating explicitly, is that such agitation eventually is so intense as to cause the corpuscles or atoms to be capable of readily moving past one another, thereby causing a solid material to melt, or be converted into a liquid. He cites the behaviour of gold as proof of his argument, saying 'that Gold (which by its being the heavyest and fixtest [here: least volatile] of Bodies, should be the most Earthy)' (318 [319].23-25), is melted, or 'brought to Fusion by a strong Fire; which sure [surely] is more likely to drive away then [than] increase its Aqueous Ingredient, if it have any' (318 [319].25-28). As further evidence, he considers the distinction between solid and liquid from 'the other side' (318 [319].29), by arguing that it is 'for want of a sufficient agitation of its minute parts' (318 [319].29 – 320.1) that 'Ice is not Fluid, but Solid' (320.1-2).

Carneades wishes now to consider how another Aristotelian element, fire, may be shown to be present in materials, according to Guntherus, who 'presumes also that the Mordicant [caustic] Quality of Bodies must proceed from a fiery ingredient' (320.2-5). Carneades does not accept this, pointing out, though not pressing his case, that the properties which would be expected to be manifestations of the presence of fire, *viz*. light and inflammability, would no longer be present in materials which have been reduced to ashes. An example he may have in mind is potash or potassium carbonate, present in wood ashes, and which is quite caustic.

As Carneades himself puts it 'not to urge [affirm] that the Light and inflamable parts, which are the most to belong to the Element of Fire' (320.5-7) would have been driven away by the heat that reduced the materials to ashes. Neither will he 'urge' (320.10) or affirm that 'Oyle of Vitriol [sulphuric acid]' (320.11) which being an incombustible, corrosive liquid, 'quenches Fire, burns the Tongue and flesh of those that Unwarily tast or apply it, as a caustick [burning or corrosive substance] doth [does]' (320.12-14). He reinforces what he has already said by pointing out that he does not accept Guntherus's line of argument for the very good reason that one cannot argue for the presence of certain qualities in compound materials without first demonstrating their presence in the elements from which these compounds are constituted. He states that 'it is precarious [dubious] to prove the Presence of Fire in fixt salts from their Caustick power, unlesse it were first shewn [shown] that all the Qualities ascribed to salts must be deduc'd from those of the Elements' (320.14-19). This, he warns 'had I time [if I had time], I could easily manifest [show] to be no easy talk[56].

Further weaknesses in Guntherus's reasoning are described by Carneades, whom he accuses of ascribing the presence of elements to materials which manifestly do not possess the attributes of these elements. He rails that a 'Body as Homogeneous as any he can produce for Elementary' (320.22-24) by which he seems to mean a body of elemental homogeneity, Guntherus considers as belonging 'both to Water and Fire, Though it be neither Fluid nor Insipid [tasteless], like Water; nor light and Volatile, like Fire' (320.24-27). He then says that he seems to omit earth as an element 'in this Anatomy [chemical analysis]' (320.27-28), 'save [except] That he

[56] Corrected to 'task' in the 1680 edition.

intimates, That the salt [here: the taste-bearing fraction] may pass for that' (320.28-29 – 321.1).

Carneades emphasises the inconsistencies of identifying two markedly different materials – salt and ashes – as constituting earth which itself is supposed to possess a constant composition. He says that since Guntherus 'takes Ashes for Earth' (321.2) a few lines earlier, Carneades cannot understand 'how he will avoid an Inconsistency either betwixt the Parts of his Discourse [account] or betwixt some of them and his Doctrine' (321.2-5). He also objects that 'since There is a manifest [obvious] Difference betwixt the Saline and the insipid [tasteless] Parts of Ashes' (321.6-8), he cannot see 'how substances That Disagree in such Notable [perceptible] Qualities' (321.8-9) can belong to the same supposed element, and this after thermal analysis is meant to have 'separated it from the admixture of other Elements' (321.14-15), 'confess'd [acknowledged] by most *Aristotelians*' (321.16) to account for the impurities found 'in common Earth' (321.17).

He proceeds to point up some inconsistencies in the Aristotelian account of some of their different elements. Considering firstly fire and air, he says that they are not so different in properties, yet each one is accorded elemental status, although in the case of wood ashes – these in fact separate into two distinct products, potash, or potassium carbonate, and an inert residue – yet these two fractions are supposed to participate in a single element, *viz*. earth. He goes on to consider 'for how little a Disparities sake' (321.19-20) the Aristotelians make 'these Symbolizing [agreeing in qualities] Bodies Aire and Fire to be two Distinct Elements' (321.21-22). This he contrasts with ashes, whose saline part 'is very strongly Tasted [having a specific taste]' (321.24) and highly water soluble. On the other hand 'the other part of the same Ashes is insipid [having little or no taste]' (321.26) and water insoluble. In addition, one of these is 'Opacous [opaque]' (321.29), the other 'somewhat Diaphanous [transparent]' (321.29 – 322.1), and differ also in 'Divers [several] other Particulars' (322.2). He makes the sensible observation that if we take into account these contradictory properties 'we shall hardly think that both these Substances are Elementary Earth' (322.3-5). Carneades seems to be referring to the production from wood ashes of the translucent, granular form of potassium carbonate, which, as he observes, is partially transparent, and which is called pearl ash.

He counters another objection, namely that the saline taste can be produced by heat-treatment alone. He points out that it requires an external source of salt for any change of composition to occur. He argues that when it is 'objected' (322.6) that the saline taste of ashes 'is only an Effect of Incineration and Adustion [burning or scorching]' (322.7-8), it has already been decisively dealt with by way of a reply to Themistius[57] and 'prov'd against him' (322.10) that 'however [by whatever means] insipid [having little or no taste] earth may perhaps by Additaments [additions] be turn'd into Salt, yet 'tis not like it should be so by the Fire alone' (322.11-14). He cites as an example gold and silver, which when refined, the 'violentest Fires We can Employ on them' (322.15-16) does not give them 'the least Rellish [distinctive taste] of Saltness' (322.17-18).

Carneades goes on to remind his companion that 'the Ashes of some Concretes [compound materials]' (322.19-20) contain little or no salt, adding that 'Refiners

[57] For which see p. 26 *et seq*.

suppose that bone-ashes are free from it' (322.21-22), allowing them to use them 'for Tests[58] and Cupples'[59] (322.23) which, he says 'ought to be Destitute [devoid] of Salt' (322.24) if high temperatures are not to 'bring them to Vitrification [converted into a glassy substance]' (322.26). Quoting from personal experience, Carneades deliberately 'tasted a Cuppel made of only bone-ashes and fair [clean] water' (322.27-29) which had been placed in a very hot fire 'acuated [sharpened] by the Blast of a large pair of Double Bellows' (323.1-3). Nevertheless he found that the extreme heat had not 'imparted to it the least Saltness, or so much as made it less Insipid [tasteless]' (323.4-6).

Not wishing to repeat other parts of the argument made earlier against Themistius, he would prefer to consider Guntherus's account, in which he claims to demonstrate the obvious presence of the four Aristotelian elements in the thermal decomposition of fresh wood. He says that as neither of them wishes to repeat any more of the points 'urg'd [alleged]' (323.9) against Themistius, he would prefer if Eleutherius would 'take notice [take heed]' (323.11) with him 'that when our Author [Guntherus]' (323.11-12) sets about delivering 'an occular [visual] Demonstration of the immediate [direct] Presence of the four Elements in the resolution of Green Wood' (323.16-18), 'He is fain [willing] to say things that agree very little with one another' (323.18-20), and this from a man of learning who 'pretends [declares] skill enough in Chymistry to reforme the whole Art' (323.13-14).

[58] A test is the movable hearth of a reverberatory furnace in which silver, for example, is separated from lead by cupellation.
[59] A cupel is a small flat circular porous vessel, with a shallow depression in the middle, moulded from bone-ash, and used in assaying gold or silver with lead.

He now lists his objections to Guntherus's analysis of the thermal decomposition products of wood. He notes that early in the Latin passage read just now by Carneades, he relates that Guntherus took the 'sweat'[60] (323.22) 'of the Green Wood to be Water, the smoke Aire, the shining Matter Fire, and the Ashes Earth' (323.23-25). He objects that a little later, not only in each of these, but as noted just now 'in one Distinct Part of the Ashes, shew [show] the four Elements' (323.27-29). He reasons from this one of two possibilities: the first is that Guntherus's experimental technique is incapable of determining the number of the elements, as the thermally decomposed residue is not reduced to its elemental state, but rather into products which still contain the four Aristotelian elements; the second is that the tests which he claims enable him to determine that all of the elements are indicated in the various decomposition products are inadequate to their task.

Carneades explains it by arguing that 'either the former *Analysis* must be incompetent [insufficient or inadequate] to prove that Number of Elements' (323.29 – 324.1-2) as the charred material has been reduced into decomposition products, themselves consisting 'of the four Elements' (324.5-6) rather than to an elemental status. Alternatively, 'these Qualities from which he endeavours to deduce the presence of all the Elements' (324.6-8), 'in the fixt [inert] salt, and each of the other separated substances, will be but a precarious [unsound] way of probation [investigation]' (324.8-11). He reinforces his argument by giving as example the potassium carbonate extracted from wood-ash, the ultimate reduction product of the combustion of wood. Potassium carbonate is a perfectly homogeneous material, he argues, so if the Aristotelians believe that it is actually heterogeneous, they will not

[60] Translated by the present author as 'exuded moisture'.

be able to prove their case by means of further thermal processing in an effort to reduce it to its constituent elements. He says that if one considers that 'the extracted *Alcali* of Wood [potassium carbonate] which 'for ought [aught] appears at least as similar [of the same substance throughout] a Body' (324.13-14) as any producible by the Aristotelians. He posits that if its different characteristics 'must argue [indicate] the presence of Distinct Elements' (324.15-16) then 'it will scarce [scarcely] be possible for them' (324.17) by any of their methods of thermal analysis 'to shew [show] that any Body is a Portion of a true Element' (324.19-20).

He checks himself, recalling that what he is now narrating is 'an occasional [incidental] excussion [diligent examination]' (324.22), intended only to point out that in the present 'Controversie [debate]' (324.24-25) both the Aristotelians and the Paracelsians take for granted something 'which they ought to prove' (324.26), but now wishes to revert to the first of his exceptions, 'and further tell you, that neither is that the only precarious [doubtful or unsound] thing that I take notice of [show awareness of] in *Sennertus*[61] his Argumentation [process of reasoning]' (324.28-29 – 325.1-2). He goes on to give an example of Sennert's taking for granted some properties of materials without any rational basis for so doing. He relates that 'because the Qualities he Mentions as Colours, Smells, and the like, belong not to the Elements [earth, air, fire and water]; they therefore must to the Chymical Principles [salt, mercury and sulphur]' (325.3-7). This Carneades objects to, arguing that Sennert is taking for granted 'which will not in haste be prov'd; as I might here manifest [show plainly]' (325.7-9), but adds that he 'may by and by [soon] have a fitter [more appropriate] opportunity to take notice [pay attention] of it' (325.9-11).

[61] Daniel Sennert (1572-1637) German-born medic and chemist, professor of medicine at Wittemberg. He accepted Paracelsus' three principles, but rejected some other parts of the Paracelsian doctrine.

Carneades is content for now to indicate a single example against Sennert's position, namely that as most properties must be founded upon some first receptacle, upon which it depends for its legitimacy, and through which the presence of this property in other materials, reputedly possessed of it, gain their validity. If the foundational belief or postulate is refuted so too is the validity of its application to those other materials reputedly containing it.

Carneades offers 'thus much [so much as this] at present' (325.11) 'to have Discours'd [conversed about] against the Supposition, that almost every quality must have some δεκτικόν πρῶτον [first receptacle]' (325.12-14), which he imagines in physical terms as 'some Native [forming the source or origin]' (325.15) 'wherein [in which] as in its proper Subject of inhesion [existing of a subject] it peculiarly [exclusively] resides' (325.16-17), 'and on whose account that quality belongs to the other Bodies, wherein [in which] it is to be met with' (325.17-19). He concludes that once 'this Fundamental supposition' (325.20) is 'Destroy'd, whatsoever is built upon it' (325.21-22) falls with it.

Carneades observes that the Paracelsians are unable either to employ their three principles to explain the properties which they associate with them or to deduce the properties of compound materials from them. He alleges 'that Chymists are (for ought [aught] I have found) far from being able to explicate [explain] by any of the *Tria Prima* [three principles], those qualities which they pretend [assert] to belong primarily [in the first instance] unto it, and in mixt Bodies to Deduce [derive] from it' (325.24-29).

He then makes the point that, in common with those who debate an issue, the Paracelsians hold that there are only two possible opinions on the matter. If the other party's opinion is wrong, they contend, then theirs must be correct. This position, Carneades argues, fails to acknowledge that in attempting to understand the workings of the created world, several explanatory hypotheses must be admitted as possible. He begins by averring that 'such qualities are not explicable [explainable] by the four Elements [earth, air, fire and water]' (325.29 – 326.1-2), but it does not necessarily follow that 'they are so by the three hermetical [chemical] Principles [salt, mercury, sulphur]' (326.3-4). This 'seems to have deceiv'd the Chymists [Paracelsians]' (326.4-5), and others 'who argue as if there could be but two Opinions concerning the Difficulty about which they contend [dispute keenly]' (326.7-10). From this 'they inferr, that if their Adversaries Opinion be Erroneous, Their's must needs be the Truth' (326.10-13). Carneades points out that for many questions 'especially in matters Physiological [relating to the material universe]' (326.13-14), there may be several hypotheses, that 'except where the Opinions are precisely Contradictory' (326.17-18) it would be 'very inconsiderate [imprudent] and fallacious to conclude' (326.16-17) 'the Truth of one from the falsity of another' (326.19-20).

Carneades offers his own solution to the difficulty posed by the failure of both elemental systems to explain the physical properties of material bodies: *viz*. the one proposed by Boyle himself, involving the twin principles of matter and motion – with matter differentiated by the size, figure, and shape of its constituent corpuscles. He pleads that in the case in hand if the 'Properties of mixt Bodies' (326.21-22) do not have to be explained 'either by the Hermetical [Paracelsian], or the *Aristotelian Hypothesis*' (326.23-24), then there are 'divers [several] other and more plausible wayes of explaining them' (326.24-26). The system he most favours is 'that, which deduces qualities from the motion, figure, and contrivance [design] of the small parts of Bodies' (326.26-29), which he thinks 'might be shewn [shown] if the attempt were as seasonable [opportune] as I fear it would be Tedious [here: time consuming]' (326.29 – 327.1-2).

Relenting somewhat, Carneades admits that the Paracelsians do have a point when they argue that the Aristotelian elemental system is inadequate to account for the properties of compound materials, and that they deserve credit for demolishing a doctrine so patently absurd. This, however, does not discharge them from the obligation to identify more effective principles than their three to account for the properties of the materials with which they concern themselves. He says that he 'will allow [acknowledge] then, that the Chymists [Paracelsians] do not causelessly accuse the Doctrine of the four elements of incompetency [inadequate] to explain the Properties of Compound bodies' (327.3-7). He believes that they deserve praise for 'this Rejection of a Vulgar [common] Error' (327.7-8), namely 'a Doctrine whose Imperfections are so conspicuous, that men needed but [only] not to shut their Eyes, to discover [reveal] them' (327.10-13).

Carneades immediately reverts to pointing up the shortcomings of the Paracelsian doctrine, declaring that it, too, is in need of more principles than those provided by their salt, sulphur, and mercury if it is to explain the qualities of the materials which they manipulate. He would, he continues, be 'mistaken' (327.13) if he denied that the 'Hermetical Philosophers [Paracelsians]' (327.14) 'need not, as well as the Peripateticks [Aristotelians], have Recourse [action of turning to] to more Fruitfull and Comprehensive Principles then [than] the *tria Prima* [three principles], to make out the Properties of the Bodies they converse [deal] with' (327.15-19).

Wishing for a 'fitter opportunity to prosecute [pursue] this Subject' (327.21-22) he will not now mention the 'obvious and familiar' (327.25) quality of colour, and 'how little Instruction we are to expect from the *Tria Prima* in those more abstruse [obscure] ones, which they [the Paracelsians], with the *Aristotelians* stile Occult' (327.25-29). He complains that not only do the adherents of the three strands of opinion disagree about colours, but none of them has given a coherent explanation of them. No one from 'the three Perswasions soever' (328.3) 'does intelligibly explicate Them' (328.24). He goes on to say that 'The Vulgar [common] Chymists are wont [accustomed] to ascribe Colours to Mercury; *Paracelsus* in divers [several] places attributes them to Salt' (328.5-7), and Sennert 'referrs Colours rather unto Sulphur' (328.10-11), having noted the opinions of those mentioned just now. Carneades adds decisively that how colours do or may 'arise from either of these Principles, I think you will scarce [scarcely] say that any has yet intelligibly explicated [explained]' (328.12-14).

Carneades goes on to give Boyle's own account of colour. He begins by mentioning the 'Experiments which he has collected about Colours' (328.16-17), then says that his interlocutor will surely 'confess [acknowledge] that bodies exhibite colours, not upon the Account of this or that Principle in them, but upon that of their Texture [constitution, structure]' (328.18-21). Colour then, is not a quality arising by some obscure manner from one or other of the elemental substances from which bodies are produced, but is, rather, a surface phenomenon, caused especially by 'the Disposition [arrangement] of their superficial [surface] parts, whereby the Light rebounding thence [from that place] to the Eye is so modifi'd, as by differing Impressions variously to affect the Organs of Sight' (328.22-26).

He then discusses the separation of sunlight into its seven constituent colours on passage through a glass prism, experiments more famously carried out some years later by Isaac Newton (1642-1727) in 1665-67, and published by him in 1672. He notes 'the pleasing variety of Colours exhibited by the Triangular glass [glass prism], (as 'tis wont [accustomed] to be call'd)' (328.27-29) and rhetorically demands: 'what addition or decrement [diminution] of either Salt, Sulphur, or Mercury, befalls the Body of the Glass by being Prismatically figur'd' (329.1-4).

In an effort to forestall any objection that such colours are not real, Carneades draws attention to some examples of real, though impermanent colours. He says that he 'will alledge [assert] against the Chymists, a couple of examples of Real and Permanent Colours Drawn from Metalline Bodies' (329.10-13). His first example concerns the heating of metallic mercury in the presence of air to form the red mercuric oxide. He will 'represent [depict], that without the addition of any extraneous body, Quicksilver [mercury] may by the Fire alone, and that in glass Vessels, be depriv'd of its silver-like Colours, and be turn'd into a Red Body' (329.13-18). The red mercuric oxide can be decomposed to the original metal by heating strongly, in other words 'from this Red Body without Addition likewise may be obtain'd a Mercury Bright and Specular [of a brilliant metallic lustre] as it was before' (329.18-21). Carneades concludes from this experiment that he can take metallic mercury, heat it to yield an oxide quite distinct in colour, physical form and properties from its parent metal, yet which in turn can be returned to its original metallic condition simply by heating. He cites this as 'a lasting Colour Generated and Destroy'd' (329.22-23) 'at pleasure, without adding or taking away either Mercury, Salt, or Sulphur' (329.23-25).

Carneades' second example is that of hardened steel and the colour fringes which develop on it during the secondary process of tempering, in which some of the hardness of the steel is reduced by heating to a lower temperature than that required to harden it. Colour fringes develop on the steel as it is heated as part of the tempering process and pass along the length of the item being worked. He describes how 'if you take a clean and slender piece of harden'd steel'[62] (329.25-27) and apply a candle flame close to the point, in a short while 'You shall perceive divers [several] Colours, as Yellow, Red and Blew, to appear upon the surface of the metal, and as it were run along in chase of one another towards the point' (330.1-6). The colour fringes moving along the shaft of the hardened metal radiate out from the heat source and at a given point 'may not only have a new colour produc'd in it, but exhibite successively divers Colours within a minute' (330.8-10) or so. Once removed from the heat source whatever patterns of colour fringes are displayed 'become Permanent, and last many years' (330.13-14). He asserts that the colour display just described 'cannot reasonably be suppos'd to proceed from the Accession [addition] of any of the three Principles' (330.15-18), irrespective of to which of them 'soever [whatsoever] Chymists' (330.18-19) 'ascribe Colours' (330.19).

[62] Carneades probably has in mind here an implement requiring a cutting edge at one end, such as a chisel.

He explains that the colour fringes generated during the tempering of steel may be eliminated by heating strongly and rehardening the item in question. It can subsequently be re-tempered by moderate heating, and the colour fringes appear, as before. He continues, 'especially considering, that if you but suddenly Refrigerate that Iron, First made Red hot, it will be harden'd and Colourless again' (330.20-23), adding that the heat required is the 'Flame of a Candle' (330.24) or 'any other equivalent heat Conveniently [appropriately] appli'd' (330.24-25). When this is done 'the like Colours will again be made to appear and succeed one another, as at the First' (330.26-28).

Carneades next draws a comparison between his own ease of continuing with his current theme and the difficulty for his adversaries in giving a satisfactory account of other qualities than they have of colours, using their three principles. Stopping in his tracks, he reminds his interlocutor that he should 'not any Further prosecute [pursue] an Occasional [incidental] Discourse [narration]' (330.28-29), adding snidely that this would not be as difficult for him to do 'as I fear it would be for the Chymists to give a better account of the other Qualities, by their Principles, then [than] they have done of Colours' (331.2-5).

He mentions Sennert again, whom he holds in high regard, arguing that he would find it very difficult to resolve many of those questions, using the three Paracelsian principles, which he calls upon the ordinary Aristotelians to answer by means of their four elements. He fears that '*Sennertus*'[63] (331.6) would have been 'exceedingly puzzl'd to resolve, by the *Tria Prima* [three principles]' (331.7-9) half

[63] Daniel Sennert (1572-1637) German-born professor of medicine at Wittemberg. He accepted Paracelsus' three principles, but rejected some other parts of the Paracelsian doctrines.

of the problems 'which he challenges the Vulgar [common] Peripateticks [Aristotelians] to explicate by their four Elements [earth, air, fire, water] (331.10-12). He continues that even allowing 'that Salt or Sulphur were the Principle' (331.13-14) to which one quality or another 'may be peculiarly [specifically] referr'd' (331.14-15), and even though the one who postulates that doctrine does teach 'us something concerning That quality, yet he Teaches us but [only] something [a small amount]' (331.16-18).

Handing on a doctrine such as this, Carneades complains, teaches very little indeed, and would not provide a sufficient demonstration of the truth. Simply stating that a particular property is inherent in a given element tells us nothing of its origin, production and the mechanism by which it acts. For teaching us the small amount just stated, would be less than adequate to 'satisfie an inquisitive Searcher after Truth' (331.20-21). It is not enough for Carneades to be told that 'such a quality resides in such a Principle or Element' (331.22-24) without knowing 'the Cause of that quality, and the manner of its production and Operation' (331.25-27).

Carneades cites as an example how little he knows 'more then [than] any Ordinary Man of Gravity [weight or heaviness]' (331.27-28) if all he knows is 'but [only] that the Heaviness of mixt bodies' (331.29 – 332.1) results from their constituent earth, if he does not know 'the reason why the Earth is Heavy' (332.2-3) likewise the 'Chymist' (332.4) teaches little to the 'Philosopher of the Nature of Purgation, if he only tells him that the Purgative Vertue [power] of Medicines reside in their Salt' (332.5-8). Carneades is here illustrating a charge levelled against the Aristotelian system of qualitative descriptions which argued that qualities were attributable to virtues or powers inherent in bodies, and in the examples just quoted, bodies are heavy because they possess the form of heaviness. Likewise, medicines were efficacious because they included in their composition specific properties; purgatives, for example, contained a purgative power, and medicines inducing sleeping possessed a dormitive power.

However, he does not go along entirely with the line of reasoning given in his question posed just now, stating that the qualitative virtues or powers present in medicines are not attributable with certainty to a specific ingredient which they contain. He points out that 'this must not be conceded without Limitation, since the purging parts of many Vegetables Extracted by the Water wherein [in which] they are infus'd, are at most but [only] such compounded Salts' (332.8-13). He elaborates on this by saying that these salts are impure, which means that their active ingredient is diluted or attenuated through admixture with other materials, such as 'Oyle, and Spirit, and Earth, as Tartar[64] and divers [many] other Subjects of the Vegetable Kingdom afford' (332.14-16).

His next example is 'that Quicksilver [mercury] precipitated either with Gold, or without Addition, into a powder, is wont [customarily] to be strongly enough Cathartical [purging]' (332.16-20). What Carneades seems to be speaking of here is calomel or mercurous chloride, which can be produced by dissolving mercury in dilute nitric acid, to form mercurous nitrate. When this is added to a hot solution of common salt, the sparingly soluble calomel is formed as a white precipitate. In earlier times calomel was used as a purgative. Gold does combine with mercury to

[64] Tartar is the crystalline substance deposited on the bottom and sides of wine casks during the production of wine.

form a liquid amalgam or alloy, but it is not clear how or why gold was in any way involved in the production of calomel.

Carneades goes on to say that ‘the Chymists have not yet prov’d, that either Gold or Mercury have any Salt at all, much less any that is Purgative’ (332.20-23). What he seems to mean is that whereas mercury can be combined with another material to form a mercury-containing purgative – calomel – the ‘Salt’ (332.22) referred to by the ‘Chymists’ (332.20) is not viewed by them as a mercury compound, but as an ingredient inherent to mercury metal. His complaint is that no such salt has been demonstrated by them as being a constituent of mercury. He adds dismissively that it is of little value to him to know ‘That ’tis the Salt of the Rhubarb (for instance) that purges’ (332.24-26), by which he probably means that the purging ingredient of rhubarb is sometimes called its ‘salt’, but ‘if I find That it does not purge as Salt; since scarce [scarcely] any Elementary Salt is in small quantity cathartical [purging]’ (332.26-29).

He is here discounting the idea of salt of rhubarb as a purgative, as salts usually do not purge, from which it follows that something defined as the salt of rhubarb is unlikely to act as one. In any event, he adds, the agency through which ‘Purgation in general is effected in a Humane Body’ (333.1-2) is not known to him or, by implication, to anyone else. Carneades reinforces his argument by stating that ‘’tis one thing to know a mans lodging, and another, to be acquainted with him’ (333.2-4). He explains what he means by saying that ‘it may be one thing to know the subject wherein a Quality principally resides, and another thing to have a right notion and knowledg[65] of the quality its self' (333.5-8).

Carneades attributes the reason for the 'Chymical Deficiency' (333.10) illustrated in the foregoing examples as 'the same upon whose account I think the *Aristotelian* and divers [many] other Theories incompetent [inadequate] to explicate the Origen of Qualities' (333.10-14). The nub of the matter, he contends, is that positing the presence, either qualitatively or at best semi-quantitatively, of certain ingredients which subsist in their parent materials as anything other than inactive bodies, is futile, as matter and motion are the two principles of physical things. He believes that 'the *Phaenomena* of Nature' (333.15-16) will never be explained by men 'while they endeavour to deduce them only from the Presence and proportion of such or such material Ingredients' (333.16-19), and crucially, when they 'consider such ingredients or Elements as Bodies in a state of rest' (333.19-20). In this they are wrong-headed as 'the greatest part of the affections [attributes] of matter, and consequently of the *Phaenomena* of nature, seems to depend upon the motion and the continuance of the small parts of Bodies' (333.21-25).

He elaborates on this by explaining 'For 'tis by motion that one part of matter acts upon another' (333.25-27), adding, 'and 'tis, for the most part, the texture [constitution or structure] of the Body upon which the moving parts strike, that modifies to motion or Impression [effective action]' (333.27-29 – 334.1), and concluding that motion 'Concurrs [combines in action] with it to the production of

[65] Not corrected to 'knowledge' in the *Errata* or the 1680 edition.

those Effects [outward manifestations] which make up the chief part of the Naturalists [natural philosophers] Theme [subject of discussion]' (334.1-4).

Having offered the foregoing exposition of the fundamental importance of motion acting on matter as the true agency by which physical changes occur, and which accounts for the production of the materials of the created world, Carneades is interrupted by Eleutherius. He points out that his interlocutor has 'left some part of what I alledg'd [asserted] in behalf of the three principles, unanswer'd' (334.6-8). He makes the plausible observation that in various materials, medicinal qualities may be present in one or other of the three principles, and the principle containing the active ingredient in question isolated and investigated for its potent substance. He opines that nothing that Carneades has said will prevent the 'useful Discovery, that since in the Salt of one Concrete [compound material]' (334.9-11) or the sulphur or mercury of two others, 'the Medicinal vertue of it resides' (334.12-13), that principle ought to be isolated 'and there the desired faculty [active quality] must be sought for' (334.15-16).

Greatly amused, Carneades admits 'that the Notion of the *Tria Prima* [three principles] may be of some use' (334.18-19), but thinks that what his companion has alleged or asserted for its utility lies in its value to 'Apothecaries [pharmacists] rather than to Philosophers' (334.21-22), explaining that 'The being able to make things Operative being sufficient to those [the Apothecaries], whereas the Knowledge of Causes is the Thing looked after by These [the Philosophers]' (334.23-26). He then advises that 'even this it self will need to be entertained [maintained] with some caution' (334.27-29).

He goes on to list the reasons why he believes one should exercise caution. The first one is that it is not certain that the medicinal ingredient of a 'simple' dissolved out by water or alcohol, forms a component part of either the salt or sulphur of the compound material. His justification for this opinion lies in his belief that water and alcohol will leach out soluble compound materials rather than elementary ones, unless fire or other powerful agent has been employed to break down the starting material. Carneades explains that it does 'not presently [immediately] follow, That if the Purgative or other virtue [power] of a simple [element or principle]' (335.1-3) may readily dissolve out in water or 'Spirit of Wine [alcohol]' (335.4) it is inherent to the salt or sulphur of the compound material. He reasons that 'unlesse the Body have [has] before been resolved [decomposed]' (335.6-7) by either fire or some other 'Powerful Agent' (335.8), by which he probably means a chemical reagent such as a strong mineral acid, the fraction removed by either water or alcohol will not be elementary, but 'rather the finer compounded parts of it self' (335.10-11).

Carneades now reiterates his understanding of the solvent power of water, listing some of the materials which it dissolves. These include, he says, 'not only pure Salts, but Crystals of Tartar,[66] Gumme Arabick,[67] Myrr'h,[68] and Other Compound Bodies' (335.13-15). Similarly, he argues 'Spirit of Wine [alcohol]' (335.16) dissolves 'not only the pure Sulphur of Concretes [compound materials], but likewise the whole substance of divers [many] Resinous Bodies, as Benzoin,[69] the

[66] Tartar is the crystalline substance deposited during wine production on the bottom and sides of wine casks.

[67] Gum Arabic is exuded by certain species of *Acacia*.

[68] Myrrh is a bitter, aromatic gum resin exuded by various Arabian and African trees of the genus *Commiphora* (family *Burseraceae*) esp. *C. abyssinica* and *C. myrrha*, which was formerly important esp. in perfumery and as an ingredient of incense, and also in Pharmacology. A tincture made from these was used medicinally as an astringent and expectorant.

[69] Benzoin is a dry and brittle resinous substance with a fragrant odour and slightly aromatic taste, obtained from *Styrax benzoin*; used in medicine and perfumery.

Gummous [gum-like] parts of Jallap,[70] Gumme Lacca,[71] and Other bodies that are counted perfectly Mixt' (335.16-22). The water and alcohol-soluble fractions obtained from the fore-mentioned materials are evidently not simple but compound materials dissolved out through solvent action, as they can be further separated by distillation. He says that the 'Extracts' (335.22) made with water or 'Spirit of Wine [alcohol] are not of a simple and Elementary Nature' (335.23-25). They are, rather, 'Masses consisting of the looser Corpuscles, and finer parts of the Concretes whence [from which] they are Drawn' (335.25-28). The proof of this is that distillation divides them 'into more Elementary Substances' (335.29-30).

Carneades next discusses the location of the useful active qualities of the three principles within materials. He argues that if a material were separated into the three principles, their very elemental purity would mean that their particular powers would be indistinguishable from one another. As this is never the case, he reasons that the so-called three principles are always compound, not simple bodies, even though one or other of these may predominate in it. He posits that with 'a Chymical resolution by he[72] Fire, 'tis seldom in the Saline or Sulphureous principle, as such, that the desir'd Faculty [active ingredient] of the Concrete [compound material] Resides' (336.3-6). He continues 'But [on the contrary] as that Titular [nominal] Salt or Sulphur is yet [still] a mixt body, though the Saline or Sulphureous Nature be predominant in it' (336.6-9), the reason being, that 'if in Chymical Resolutions the separated Substances were pure and simple Bodies, and of a perfect [unmixed] Elementary Nature; no one would be indued [invested or provided] with more

[70] Jallap is a purgative drug obtained from the tuberous roots of the *Exogonium* (*Ipomaea*) *Purga*, and some other convolvulaceous plants.
[71] Gum lac is the dark resinous incrustation produced on certain trees by the puncture of an insect *Coccus* (or *Carteria*) *lacca*, used in the East as a scarlet dye. Shellac is derived from it.
[72] Corrected to 'the' in the 1680 edition.

Specifick Vertues, than another' (336.9-14). Consequently, 'their qualities would Differ as Little as do those of Water' (336.14-15).

He provides a practical example of this, citing the case of chemical compounds useful to human life, which he believes are far more efficacious than the pure elements. He adds 'upon the bye [in passing], That even Eminent Chymists have suffer'd [allowed] themselves to be reprehended [reproved]' (336.16-18) for paying too much attention to their purification of some thermal decomposition products of compound materials. He argues that even though 'such compleatly purifyed Ingredients of Bodies might be more satisfactory to our Understanding; yet others are often more useful to our Lives' (336.21-25). He holds that their efficacy depends mainly upon either 'what they retain of the Bodies whence [for which] they are separated, or gain by the new associations of the Dissipated [dispersed] among themselves' (336.27-29 – 337.1). By contrast he believes that if these materials were 'meerly [purely] Elementary, their uses would be comparatively very small; and the vertues [powers] of Sulphurs, Salts or Other such Substances of one denomination [title], would be the very same' (337.2-6).

Carneades says to his companion, by way of an aside, that what he has just said of the lack of real distinction between the useful properties of the three principles, leads him to the conclusion that the thermal degradation of compound materials 'into their supposed Principles' (337.11-12) yields little of benefit to humanity, by contrast, the decomposition products themselves may be useful 'as upon the score of its making new compounds by now[73] combinations of the dissipated [dispersed] parts of the

[73] Corrected to 'new' in the 1680 edition.

resolv'd Body' (337.12-15), the reason being that this leads to a larger 'Number of mixt Bodies' (337.16). He adds that 'many of those new productions are indow'd with useful Qualities, divers [several] of which they owe not to the body from which they were obtein'd, but to Their newly Acquired Texture [structure or constitution]' (337.17-22).

He offers his third argument on identifying the portion of material bodies in which their active qualities are located. He again acknowledges that his adversaries associate these with one or other of their three elemental principles, employed in the broader sense, and that they hold that breaking down the compound material will separate off the desired principle. They also maintain that in some bodies the most valuable active qualities are not to be found in any of the three principles but rather within the physical constitution of the compound material. In either case employing thermal degradation to isolate the desired quality is wrong as it serves only to destroy it. He notes, thirdly, 'that as there are divers [many] Concretes [compound materials] whole Faculties [active qualities] reside in some one or other of those differing Substances that Chymists [Paracelsians] call their Sulphurs, Salts, and Mercuries' (337.24-28), a principle may best be isolated from the others by 'analysing [decomposing] the Concrete' (337.29 – 338.1). He continues that there are 'other[74] wherein [in which] the noblest [not capable of destruction by fire] properties lodge not in the Salt, or Sulphur, or Mercury, but depend immediately [directly] upon the form'[75] (338.3-4). In other words 'result from the determinate structure of the Whole Concrete' (338.7-8). He adds ruefully that those who try to

[74] Corrected to 'others' in the 1680 edition.
[75] Here'form' is used in its Aristotelian sense, and he goes on to give us his understanding of the term.

'extract the Vertues [powers] of such bodies' (338.9-10) by means of thermal decomposition merely act to destroy what they are seeking.

Carneades goes on to discuss van Helmont's views on the subject, saying that firstly, he 'confesses [acknowledges], That as the Fire betters [improves] some things and improves their Vertues [powers], so it spoyles [destroys] others and makes them degenerate [degenerates them]' (338.16-19). The same author, secondly, 'judiciously [prudently] affirmes, that there may be sometimes greater vertue [power] in a simple[76] such as Nature has made it' (338.20-22) than in any product of thermal degradation. Van Helmont offers the following 'ingenuous [innocently frank] confession [acknowledgement]' (338.27) as confirmation that he 'means by the vertues [powers] of things those that are Medical' (338.25-26), which may be translated as:

> 'I believe (sayes he) that simples in their simplicity are sufficient
> to cure all diseases' (338.28-29).[77]

He goes on to say 'Nag. Barthias,[78] even in a Comment upon *Beguinus* [Jean Beguin], scruples [hesitates] not to make this acknowledgement' (339.1-3), which may be translated as:

> 'It is most absurd (sayes he) that salts, the fifth essences, can be extracted from all things; especially from substances clearly in themselves either fine-

[76] Here: a medicine or medicament composed of only one constituent.
[77] '*Credo* (sayes he) *simplicia in suae simplicitate esse sufficientia pro sanatione omnium morborum*.'
[78] Corrected to 'Nay, Barthius' in the 1680 edition.
This may be a reference to Jeremias Barth, a German-born pupil of Jean Beguin, and at whose instigation the latter wrote his *Tyrocinium Chymicum* [Chemistry for Beginners], published in 1610.

structured or homogeneous such as single large pearls, corals, musk, amber, etc.' (339.3-8).[79]

Carneades continues that the same author 'Consonantly whereunto [consistently unto which]' (339.8) says '(and Vouches [cites] the famous *Platerus*,[80] for having candidly given the same Advertisement [information] to his Auditors [attendants on lectures],) that some things have greater vertues [powers]' (339.9-12) and agree better with our systems 'when unprepar'd' (339.13-14) than when processed using heat. The example Platerus gives is pepper, of which some grains swallowed perform more towards the relief of a Distempered [disordered] stomack' (339.16-18), than a large quantity of its oil.

He now gives some further examples of how, when materials are reduced into smaller components, the decomposition products bear few characteristics of their parent bodies. In his first example he refers to 'our Friend here present' (339.21-22) – Boyle himself – who has found that saltpetre, nitre or potassium nitrate, when subjected to thermal decomposition, none of 'the substances into which the Fire is wont [accustomed] to divide it, retaines either the Tast, the cooling vertue [here: property],[81] or some other of the properties of the Concrete [*i.e.* potassium, nitrate]' (339.23-27). He remarks that 'each of those Substances acquires new qualities, not to be found in the Salt-Petre it self' (339.27-29).

[79] ' *Valde absurdum est* (sayes he) *ex omnibus rebus extracta facere, salia, quintas essentias ; praesertim ex substantiis per se plane vel subtilibus vel homogeneis, quales sunt uniones, Corallia, Moschus, Ambra, &c.*'
[80] Felix Platter (1536-1614) Swiss-born physician and professor at Basle.
[81] When saltpetre is added to water the energy required to solvate it is removed from the water, thereby causing the temperature of the solution to decrease.

Carneades' next example concerns the inability of the 'shining property of the tayls of gloworms' (340.1) to continue glowing any longer once they have been separated from the creature's body. He continues that 'inquisitive men have not scrupled [hesitated] publickly to deride *Baptista Porta*'[82] (340.3-5), among others, who Carneades believes may have been deluded 'with some Chymical surmises [conjectures]' (340.6-7) when they 'ventur'd to prescribe the distillation of a Water from the tayles of Glowormes, as a sure way to obtain a liquor shining in the Dark' (340.7-10).

His final example is provided by amber, a fossilised resin, which since ancient times has been noted for its tendency to build up a static electrical charge on its surface by rubbing with a silk cloth, for example, and is thereby 'endow'd with an Electrical faculty [capacity] of drawing to it self fethers, strawes, and such like Bodies' (340.13-16). He notes that he could never observe this quality 'either in its Salt, its Spirit, its Oyle'[83] (340.17). Neither could he replicate this property in 'the reunion of its [amber's] divided Elements; none of these having such a Texture [constitution] as the intire Goncrete'[84] (340.19-21). What Carneades may have done is distill some amber, then take its succinic acid, which with a melting point of 184-186^{o}C, would be a solid at room temperature, and the amber oil which also had distilled over from it, and heated them together until the succinic acid melted, then cooled the combined products to form a solid, or semi-solid mass, none of which derivatives would have possessed the hardness of amber. Hence his observation that the distillation products lacked the 'Texture' (340.20) or constitution of their parent.

[82] Giambattista Della Porta (1535?-1615) Italian-born scholar, published his *Magiae Naturalis* [Natural Magic] in 1558.
[83] When amber is dry distilled it yields succinic acid, formerly called the salt or spirit of amber.
[84] Corrected to 'Concrete' in the 1680 edition.

Carneades goes on to criticise his adversaries for linking the properties of materials with the presence and amount of their constituent elements, and although conceding that these may have a bearing on the properties of a material it is, he contends, the manner of the arrangement of the bodies' constituents that primarily determines their properties. He argues that 'however Chymists boldly [presumptuously] deduce such and such properties from this or that proportion of their component Principles' (340.21-24), it is 'not alwayes so much by vertue of its presence, nor its plenty' (340.26-27) of a given ingredient in a 'Concrete [compound material]' (340.28) that makes it 'qualify'd [possessed of suitable qualities] to perform such and such Effects [results]' (340.28-29). It is, instead, the 'texture' (341.1) or the structure or constitution of the component materials, 'associated after a determinate Manner into one Concrete [compound body]' (341.2-3), even though it may be that 'such a proportion of that ingredient may be more convenient [suitable, appropriate] than an other for the constituting of such a body' (341.4-7).

In keeping with his espousal of the mechanical philosophy, Carneades cites the examples of the working of a clock as a means of illustrating his argument that the nature of the component parts of the system are, at most, only partially responsible for the performance of the clock. It is, he posits, the arrangement of the parts which enables them to act in concert and behave as a functioning clock. He explains that 'in a clock the hand is mov'd upon the dyal, the bell is struck' (341.7-8), and the mechanism operates, 'not because the Wheeles are of brass or iron' (341.10-11), or of mixed metals, 'or because the weights are of Lead' (341.12-13), 'but by Vertue of the size, shape, bigness, and co-aptation [fitting together] of the several Parts'

(341.13-15), each of which would perform perfectly well ‘though the wheels were of Silver, or Lead, or Wood, and the Weights of Stone or Clay’ (341.16-18). He does concede ‘that Brasse and Steel are more convenient [suitable] materials to make clock-wheels of than Lead, or Wood’ (341.21-24).

Continuing to reinforce his argument on the importance of the disposition or arrangement of materials at the microscopic level, he quotes an example based on his own experience, namely the behaviour of lead when heated. He wishes to explain to his interlocutor that ‘sometimes at least’ (341.25) it is ‘the Texture [constitution, structure] of the small parts of a body, and not alwayes upon the presence, or recesse [(temporary) withdrawal], or increase, or Decrement [decrease] of any one of its Principle,[85] that it may lose or gain some qualities considered as ‘very strongly inherent to the bodies they Reside in[86] (142 [342].2-3). He ‘will add’ (142 [342].4) to the relevant parts of his ‘past discourse [account, narration]’ (142 [342].4-5), and drawn from his own experience, ‘this Notable [worthy of attention] Example’ (142 [342].5-6). He goes on to say ‘That Lead may without any additament [addition], and only by various applications of the Fire, lose its colour’ (142 [342].7-9), by which he may mean the replacement of the grey colour of lead at room temperature with the silvery molten metal. It ‘acquires sometimes a gray’ (142 [342].10), this is probably a reference to the thin layer of lead monoxide forming on the surface of the newly melted metal, followed by ‘sometimes a yellowish, sometimes a red, sometimes a *amethihstine* [amethystine or violet-purple] colour’ (142 [342].10-12). What Carneades seems to be referring to here is the variations in colour resulting from the changes in crystal structure of the lead monoxide formed in the heating of

[85] Corrected to ‘Principles’ in the 1680 edition.
[86] Corrected to ‘in;’ in the *Errata*.

lead metal. Above 458^{o}C lead monoxide exists as massicot which occurs in the orthorhombic lattice structure and is yellowish in colour. Below this temperature the lead monoxide exists as litharge in the tetragonal lattice structure and has a reddish colour. The violet-purple colour probably results when molten lead in freshly cooled and just before a more obvious grey film of lead monoxide has formed on its surface. When it has 'past through these, and perhaps divers [several] others, again recover its leaden colour [through oxidation], and be made a bright body' (142 [342].12-15). The last named form of lead results, perhaps, when the metal is scratched or freshly cut.

Carneades goes on to relate further properties of lead, the first of which is 'this Lead, which is so flexible a metal, may be made as brittle as Glasse and presently be brought to be again flexible and Malleable as before' (142 [342].15-19). What he seems to be referring to here is crude lead, which is hard due to the presence as impurities of copper, antimony and bismuth. The impure metal is softened by melting on the hearth of an appropriate furnace until the foreign metals are oxidised and form a scum on the surface, mixed with some lead monoxide or litharge.[87]

He then states that 'the same lead' (142 [342].20) which microscopic examination reveals 'to be one of the most opacous [opaque] bodies in the World' (142 [342].21-22) 'may be reduced to a fine transparent glasse' (142 [342].22-23). This change is reversible, and this product 'may returne to an opacous Nature again' (142 [342].23-24) 'without the addition of any extraneous body' (142 [342].25-26) by the application of heat as appropriate. What Carneades may be speaking about is the

[87] See also Partington, *General and Inorganic Chemistry*, 525.

production of the reddish-yellow scales of litharge, which, as already mentioned, is a form of lead monoxide, produced by heating lead, and which itself can be reduced to the metal by heating in the presence of a carboniferous fuel.

Realising that he has spoken at some length, putting his companion 'to so prolix [long-winded] a trouble' (343.1), he promises to put 'speedily a period [an end] to it' (343.3). Now he will only 'from all that I have hitherto discoursed [narrated]' (343.5), with him 'deduce but [only] this one proposition by way of Corollary [immediate inference]' (343.6-7). He gives this as:

> '*That it may as yet be doubted, whether or no there be any determinate Number of Elements*;' (343.7-9),

then restates it:

> '*Or, if you please, whether or no all compound bodies, do consist of the same number of Elementary ingredients or material Principles* (343.9-12).

Carneades takes it that as this is no more than 'an inference from the foregoing Discourse [conversation], it will not be requisite [necessary] to insist [dwell at length on] at large on the proofs of it' (343.13-16). He will now no more than indicate the most important of these, as he believes that their details have already been stated.

Firstly, he argues 'from what has been so largely discours'd [reasoned]' (343.19-20). He sees that the customary experiments of both 'common Peripateticks [Aristotelians], or by the vulgar [common] Chymists' (343.22-23) 'do not evince [prove] what they are alledg'd [asserted] to prove' (343.27-28), namely that all compound materials are made up 'precisely either of the four Elements, or the three Hypostatical [elemental] Principles' (343.25-27). He next considers the arguments put forward by the Aristotelians, in support of their four-element system, by making a series of contrasts. The first contrast is between the usual arguments ‘pretended [claimed] to be drawn from Reason’ (343.29 – 344.1) by the Aristotelians, and those of the Paracelsians, of whom he says ‘the Chymists are wont [accustomed] to rely almost altogether upon Experiments’ (344.2-4).

Carneades’ second contrast is between the flimsy nature of the arguments of the Aristotelians and the ease of overturning them. For these arguments ‘are Commonly grounded upon such unreasonable or precarious Suppositions’ (344.4-6) that they are indeed ‘as easie and as just [well-founded]’ (344.7) for them to be rejected by one as to be asserted by another, as all of them are ‘as indemonstrable as the conclusion to be inferr’d from them’ (344.10-11). Finally, the feebleness of the arguments is such that only the most indulgent and maladroit could allow them. Some of them are ‘so manifestly [obviously] weak and prooflesse’ (344.12-13) that only a ‘very courteous [gracious or deferential] adversary’ (344.13-14) could grant them, and ‘as unskilful a one, that can be compelled to do so’ (344.15-16).

He goes on to state that as there are two stated means by which compound materials can be resolved into their elemental ingredients, namely, thermal decomposition and solvent dissolution, but as the two methods do not yield the same elements, it would have to be decided which system of resolution to adopt, so that it might be ascertained how many elements there are. He believes that ‘if what those Patriarchs [founding fathers] of the *Spagyrists* [here: those who practice alchemy or chemistry] *Paracelsus* and *Helmont*’ (344.18-19) in several instances state as true ‘namely that the *Alkahest* [universal solvent] does Resolve all mixt Bodies into other Principles than the fire' (344.20-23), then a decision must be made as to which of the two systems of resolution 'shall determine the number of the Elements, before we can be certain how many there are' (344.25-28).

Carneades continues by noting two points made by van Helmont in relation to his *Alkahest* or universal solvent. The first is that the dissolution products of this are different from those resulting from thermal degradation; the second is that not all materials yield the same number of dissolution products. We, meanwhile, 'take notice [note] in the last place' (344.29 – 345.1) 'that as [as it were] the distinct [separate] substances whereinto [into which] the *Alkahest* [universal solvent] divides bodies, are affirm'd [asserted strongly] to be differing in nature from those whereunto [unto which] they are wont [accustomed]' (345.1-5) to be degraded by thermal decomposition. In addition some dissolved bodies provide more products than others, since van Helmont says that 'he could totally reduce all sorts of Stones into Salt only, whereas of a coal he had two distinct [separate] Liquors' (345.11-13).

Not only do different bodies yield different numbers of thermal decomposition products, but changes to the conditions employed lead to changes in the number of products. Carneades explains that 'although we should acquiesce [concede] in that resolution which is made by fire' (345.14-15) we find that compound materials are not separated 'into the same number of Elements and Principles' (345.17-18) with 'Some Concretes [compound materials] affording [providing] more of them than others do' (345.18-19). Not only this but sometimes one material or another gives 'a greater number of Differing substances by one way of management, than the same yields by another' (345.21-23).

Carneades offers a direct challenge to his adversaries, inviting them to enlighten him by separating some metallic or inert materials into as many components as he can obtain from some compound materials. He taunts them with mock humility, advising that 'I shall very Thankfully learn' (345.28-29) from those who might teach how 'out of Gold, or Mercury, or Muscovy-glasse[88] will draw me as many distinct substances as I can separate from Vitriol [iron sulphate] or from the juice of Grapes variously orderd' (345.24-28) or managed in a specified manner, by which he probably means the various products obtained from both fresh and fermented grapes, as recounted on pp. 412-416.

He adds to this line of reasoning a final argument in which he questions the value of a system of nature in which all compound materials are composed of an equal number of elements. He posits that it does not 'appear more congruous [conformable] to that variety that so much conduceth [contribute] to the perfection of the Universe' (345.29 – 346.1-3) for the 'elemented bodies' (346.3) to consist of 'the same number of Elements' (346.4-5) than it would for the words of a language to 'consist of the same number of Letters' (346.6-7).

[88] Muscovy glass (from Muscovy, the principality of Moscow) which is the mineral muscovite, especially as used to make translucent windows.

A Commentary on
The Sceptical Chymist
of Robert Boyle:
The Sixth Part

Introductory Remarks

The central theme of this section of the book is, to quote Boas (*q.v.*) that, 'it denies the validity of any theory proclaiming the existence of true, immutable elements.' Transmutation as an agent of change is explored in this chapter. Water as the primal element from which animals and plants are produced through transmutation is discussed (352-356).

Carneades opines that water may be transmuted into minerals, quoting several authors on the subject (356-366), and posits the mechanism by which he believes it to occur (358, 364). In tracing the growth of a vine from vine-slip to grapes, and the products derived from these, from wine to vinegar, Carneades can posit that all of the requisite changes are due to the transmutation of water, possibly in conjunction with some agent present in the air (412-415). In addition, vinegar may be reacted with lead oxide to form lead acetate, which may in turn be distilled to yield further products. Carneades holds that all of these products may be accounted for by alterations in the arrangements of the corpuscles of which the starting materials are constituted (421-423).

COMMENTARY: *The Sixth Part*

THE SCEPTICAL CHYMIST

OR,

A Paradoxical Appendix to the Foregoing Treatise.

The Sixth Part

What Boyle means by a ‘Paradoxical Appendix’ is unclear. Perhaps he means that the dialogue between the different friends has ended, leaving only Carneades and Eleutherius to continue with the discussion; hence Boyle speaks of the two of them rejoining ‘the Rest of the Company’ (347.7-8), indicating that the other parties to the dialogue, who, with the wider conversation having finished, had left the table and moved away to a different part of the garden. That Boyle regards the wider discussion as having ended seems to be made clear by his spokesman Carneades who speaks of having ‘dispatch’t’ (347.1) the arguments of the chemists in support of their three principles: salt, sulphur and mercury.

Eleutherius sees nothing to prevent them from continuing with their discussion on the elements, and observes that Carneades having doubted the existence of ‘any Determinate Number of Elements’ (348.7) may be inclined to question the existence of any elements at all. This possibility he acknowledges as a paradox, but believes that they had already devoted so much time to the discussion of the elements that by revisiting some of the points already raised Carneades could decide how he might make use of any of these and what he might ‘inferr’ (348.18) from them.

What they do is begin discussing a new subject – that of the actual existence of the elements. This he agrees to do in order to justify or explain his ‘Paradox’ (348.14 and 28): that there may, in fact, be no elements at all. That this is a new and unanticipated turn of events is emphasised by Carneades who is now faced with discussing the subject of the existence of the elements ‘*Ex Tempore*’ (348.27) that is, without prior preparation.

Carneades decides to deal with the question in hand by addressing himself only to the doctrine of the chemists on the three elements: salt, sulphur and mercury, rather than to that of the Aristotelians and their four elements: earth, air, fire and water. He justifies this approach by stating that the doctrine of the chemists is more highly regarded by contemporary or near-contemporary practitioners, as they believe it to be ‘grounded upon Experience’ (349.17-18).

Carneades, however, wishes to accept two of the elements of the Aristotelians or Peripatetics, namely earth and water. Their other two elements – air and fire – he dismisses as implausible. The doctrine of the presence of a fiery layer above the air surrounding a static earth, as posited by Aristotle, Carneades says is by ‘Judicious Men exploded’ (349.27-28) as an imaginary state of affairs. He dismisses the notion that air is a constituent of bodies produced from the four Aristotelian elements; air as a component of material bodies he does accept, but only as filling in the interstices of lighter bodies.

Carneades then goes on to give what is Boyle's most famous and frequently quoted definition of the elements, and immediately goes on to consider whether any one substance complying with this definition is to be found in all bodies said to be 'Elemented' (350.22).

He begins his investigation by saying that he cannot deny the existence of such bodies as earth, water, quicksilver [mercury] and sulphur, but qualifies this simple assertion by stating that earth and water are somehow distinct from other materials in that he regards them as the primal substances of the creation of the earth itself, and not mere constituents of all mixed bodies. He reverts to an older, more traditional account of matter by speaking of a 'running mercury' (351.5) as sometimes being obtained, or a combustible substance from a mineral or a metal, by saying that he does not have to accept that these substances are necessarily elemental.

Carneades goes on to state the method by which he will investigate the question of the elements by averring that 'in matters of philosophy, this seems to me a sufficient reason to doubt of a known and important proposition, that the Truth of it is not yet by any competent proof made to appear' (351.13-18).

Having set out his rationale in the investigation of the presence of the elements in actual materials, he goes on to give the two considerations that induce men to think that there are elements. The first, that nature 'make use of Elements to constitute the bodies that are reputed Mixt' (351.28-29 – 352.1), and the second, that the 'Resolution of such bodies' (352.2) demonstrates that they have been produced from elements. He reminds us of his experiments on the growth of various plants 'out of fair water' (352.12). Carneades reiterates his argument which suggests that plant tissue may result from the transmutation of water, and uses this observation to remind the reader once again that the three Paracelsian elements 'Salt, Sulphur, or Spirit [mercury]' (352.17) are not necessarily elements at all.

In mentioning 'Mounsieur de Rochas' (352.24-25) and his belief in the generation of both plants and animals from water,[1] Carneades repeats his own belief that plants can be produced from this liquid alone. Although he acknowledges that 'Wormes or other insects' (353.5-6) can be produced in putrefying plant material, nevertheless he believes that these creatures are not produced directly by the decaying plant but by 'Various Seminal Principles' (353.8) acting on the water already present in the plant tissue.

De Rochas seems to have believed in the spontaneous generation of living things, a doctrine going back at least as far as Aristotle, who says that some bloodless animals: '…come into being not from a union of the sexes, but from decaying earth and excrements' (*Generation of Animals*, 715^{a} 24-25).[2] Although the doctrine of the

[1] Henricus de Rochas, Sieur d'Ayglun, lived in the early part of the seventeenth century in Paris, was councillor and physician to the king, and wrote some books on medicine and mineral waters.
[2] Jonathan Barnes, ed., *The Complete Works of Aristotle* (Princeton: Princeton University Press, 1984), 1111.

spontaneous generation of lower life forms persisted long after Boyle's time, Carneades is careful here to distance himself from it.

Having acknowledged his belief that animals as well as plants may be produced through transmuted water acting on the appropriate seeds, Carneades then says that not elemental but 'disguised water' (353.20) may be sufficient for such transmutations in the form of 'Grass and other Vegetables' (353.19). He believes that minerals also may be produced from water. He goes on to take this argument further by saying that several plants and animals may be produced from compound bodies rather than elemental water. In making this point Carneades seems to want to state that chemical change or transmutation in living things is not effected purely by the transformation of water into plant and animal tissue, or indeed into other substances. He goes on to list a variety of examples in support of his case: 'divers men' (354.4), 'sheep' (354.8), 'magots' (354.12) and 'corn and other vegetables' (354.17-18).

He then goes on to discuss what he considers to be an interesting case of transmutation which occurs when one type of fruit tree is grafted into another – the example he gives is 'the Ciens [scions] of a pear upon a white-thorne' (354.28-29). He remarks that a graft in producing its fruit must somehow change the sap originating in the root-stock to that which runs in the graft itself, and that the change must occur either by the action of the 'root, or in its ascent by the bark, or both wayes' (355.1-2). It might be remarked that although in Boyle's time photosynthesis had not yet been discovered, he seems to have had an inkling that plant growth involved parts of the plant other than just the roots. (See also van Helmont's tree growing experiment on pp. 112-114). Nevertheless he does seem content to accept that the root-stock alone accounts for the production of whatever fruit the tree bears, even though a pear scion grafted onto a whitethorn root-stock produced pears and not haws as fruit.

Carneades reinforces his point on the production of compound bodies from other compound materials rather than from water by noting that the blood of an animal has a fixed composition even though it is produced by the combining of materials which are themselves compound. This, he believes, is possible through the operation of 'one presiding form' (355.22), and that this explanation accounts for blood being 'a strangely Decompounded [further compounded], Body' (355.23).[3] Carneades then moves on to discuss the production of metals and minerals, but states as a caveat that now he must rely on 'observations' (356.13) instead of 'experiments' (356.12). He gives an account of the production of calcium carbonate, in the form of calcite, in '*Les Caves Gentieres*' [corrected in the *Errata* to '*Goutieres*'] (356.20-21) in France, when he speaks of drops 'falling either severally or upon one another and coagulating presently into stone' (356.24-26). Carneades is here attempting to account for a geological process, *i.e*. the formation of calcite structures, a century or so before the birth of the science of geology. It is now understood that in limestone areas rainwater containing dissolved atmospheric carbon dioxide, being acidic, may

[3] In Aristotelian thought the 'form' is the structure of nature that is imposed upon matter to make the different kinds of substance in the world. In this case the 'form' of blood gives this material its particular identity.

dissolve limestone to form a solution of calcium carbonate. This solution may, in underground caves, deposit its dissolved calcium carbonate through evaporation to form accumulations of the mineral calcite as structures in the cave roof, such as stalactites and calcite curtains, and on the cave floor as stalagmites and gours. The timescale of these processes is measured in millennia and, of course, this would not have been either understood or, perhaps, accepted by Boyle, who, as a believer in the Biblical account of creation would most likely have accepted Ussher's calculated date of creation as 4004 BCE. And although Carneades does say that the growth or increase of minerals usually takes place over an 'excessively long time' (356.9), he probably means long in relation to the timescale of any experimental work he might have carried out on the matter.

Boyle would, therefore, have had to seek an explanation of calcite formation by which it occurred over quite a short timescale. In addition, in not actually understanding the process by which calcite forms, *i.e*. evaporation of water and deposition of the mineral, he would have had to provide a mechanism by which this occurred. He was, perhaps, influenced in his thinking by Aristotle's *Meteorology*, in particular by the latter's account of the formation of hailstones, amber and calcite, for which see *Mete*. I. 348^{a} 15-36.

Carneades says that some friends did him 'the favour to present me with some that they brought thence' (357.1-2), which shows that Boyle had possession of some pieces of the calcite structures of which Carneades speaks and whose formation he is attempting to explain. He then goes on to speak of van Linschoten.[4] Again, Carneades is relying on second-hand information, in this case on the production of diamonds, by van Linschoten and 'Another good Author' (357.4-5). Both van Linschoten and Carneades seem to believe that diamonds, once removed, are regenerated in the earth. The latter adds enigmatically that it is probably the case that 'Nature does always stay for divers Elementary Bodies, when she is to produce stones' (357.14-16), meaning perhaps that the materials and powers necessary for the production of stones are always present in the location where they are produced, without nature having to halt her production of them whilst waiting for the regeneration, or arrival, of the simple bodies from which they are made. Carneades goes on to discuss the growth of minerals, citing as his authority 'many testimonies of professed Chymists' (357.23-24), and thinks it best to give quotations from 'more unsuspected [not considered suspicious or doubtful] writers' (357.27). Here is a translation of the Latin passage given on 357.27-158 [358].7:

> 'Mining records testify that a sulphur mine (as the inquisitive P. Fallopius[5] notes) which is the nurse of the subterranean heat of the smith or originator of underground springs and minerals, is quickly renewed. For there are places from which if this year the sulphur were dug out and left for a period of four years, the miners would return to discover the whole place filled again with sulphur.'[6]

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[4] Jan Huyghen van Linschoten (1563-1611) Dutch explorer who served in Portuguese Goa, and wrote two books about the people and customs of India. He also sailed to the Arctic with Wilem Barents in search of a northeast passage to the orient via the Arctic.

[5] Gabriele Falloppio or Gabriel Fallopius (1523-62) Italian anatomist, who contributed greatly to early knowledge of the ear and reproductive organs.

[6] ' *Sulphuris Mineram* (as the inquisitive *P. Fallopius* notes) *quae nutrix est caloris subterranei fabri seu Archaei fontium & mineralium, Infra terram citissime renasci testantur Historiae Metallicae.*

Carneades then quotes a passage from Pliny the Elder[7] which translates as follows (on 158.7 [358].7-13):

> 'In the Italian island of Elba iron metal grows. Strabo[8] very clearly said that the metal, having been dug out there, is always regenerated. Even if the excavations are left for a period of a hundred years and are returned to again the miners come back to find the greatest amount of iron regenerated.'[9]

Carneades continues that this 'history [account] not only is countenanced [supported] by Fallopius' (158 [358].14-16) but, more to the point, is mentioned by the 'Learned Cesalpinus' [10] whose Latin quotation (158 [358].19-24) may be translated as:

> 'The supply (sayes he) of the greatest abundance of iron is in Italy; for this reason the island of Elba in the Tyrrhenian Sea has an incredible abundance which even now in our own times it produces: for the ground which is excavated until a vein of ore is completely exhausted is afterwards transformed into a new one.'[11] [12]

Sunt enim loca e quibus si hoc anno sulphur effossum fuerit ; intermissa fossione per quadriennium redeunt fossores & omnia sulphure, ut autea , rursus inveniunt plena.'

[7] Gaius Plinius Secundus (23/24 – 79 CE) multi-talented Roman, best known for his highly influential *Natural History,* which runs to thirty-seven books.

[8] Strabo (64/63 BCE – 23? CE) Greek geographer and historian, best known for his *Geography*.

[9] '*In Italiae Insula Ilva, gigni ferri metallum.* Strabo *multo expressius ; effossum ibi metallum sempre regenerari. Nam si effosio spatio centum annorum intermittebatur,& iterum illuc revertebantur, fossores reperisse maximam copiam ferri regeneratam.*'

[10]Andreas Cesalpinus / Cesalpino or Caesalpinus (1519-1603) Italian natural philosopher, studied anatomy and medicine, and was the most distinguished botanist of his time.

[11]' *Vena* (sayes he) *ferri copiosissima est in Italia ; ob eam nobilitata Ilva Tirrheni maris Insula incredibili copia, etiam nostris temporibus eam gignens : Nam terra quae eruitur dum vena effoditur tota, procedente tempore in venam convertitur*.'

[12] It is interesting to note that Elba, despite its small size, has yielded an estimated 60 million tons of iron-ore over the last three millennia. See L. Picardi and W. Bruce Masse eds., *Myth and Geology* (London: The Geological Society, 2007), 229.

Carneades draws an insight into the production of metals from the 'last clause' (158 [358].25) of the foregoing by saying that 'earth, by a metalline plastick principle latent in it, may be in processe of time chang'd into a metal' (158 [358].27-29). He may well be showing the influence here of the Cambridge Platonist Ralph Cudworth (1617-88).[13] Carneades once again speaks of the growth of iron as occurring through an organic process, this time quoting the authority of Agricola,[14] who speaks of iron being dug up 'in the fields' (359.7) which later comes to be regenerated. This may be a reference to the production of bog iron. He adds that the same metal is 'wont [in the habit of] to be obtain'd in *Elva* [Elba]' (359.12-13).

Carneades goes on to speak of lead, which, according to Galen[15] 'will increase both in bulk and weight if it be long kept in vaults or sellars' (359.15-17), and continues about the 'smelling of those pieces' (359.18-19). This is a curious statement as the word 'smelling' seems inappropriate here. Lead does indeed increase in bulk and weight through the formation of a white protective film of basic lead carbonate, when stored in moist air, so the word 'swelling' would seem to fit in better here.

[13] In his *The Digression concerning the Plastick Life of Nature, or an Artificial Orderly and Methodical Nature*, Cudworth identifies various 'Plastick Natures', including the 'General Plastick Nature of the Universe', and it is [he says] 'not impossible that there may be other Plastick Natures also'. In: C. A. Patrides, ed., *The Cambridge Platonists* (Cambridge: Cambridge University Press, 1980), 322.
[14] Agricola, Latinised form of Georg Baur (1494-1555) whose work *De re metallica* (On Metallurgy) is a source of abundant information on mining, metals and minerals.
[15] Galen (129-199/200 CE) of Pergamun, in modern Turkey, physician, biologist, philosopher and philologist, chiefly remembered for his contributions to medicine.

Carneades then quotes a passage from '*Boccacius Certaldus*'[16] (359.22) which is translated hereunder (given on 358.25-360.10).

> 'Mount Fiesole (sayes he) in Etruria, which overlooks the city of Florence, has deposits of lead ore; which if dug out are very quickly renewed by fresh growths; as (annexes my Author) Boccaccio is telling us when he writes about it so authoritatively. This is nothing new, because on the same subject Pliny, in Book 34, *Natural History*, Chapter 17, published some time ago, says astonishingly, that these lands of lead mines when abandoned, revive even more abundantly. In the low-grade lead ore at Amberg,[17] slag heaped in piles, when set apart in a safe place, having been exposed to the sun and rain for a few years, restores the metal with interest.'[18]

Carneades moves on to discussing the production of gold and silver, then gives a quotation from 'Gerhardus the Physick Professor'[19] (360.17). This passage is given on 360.18-27, and translates as follows:

> 'In Joachimica Valley (sayes he) silver grows in the mode and manner of grass from the stones of ore, just as though it had grown from the root, to a

[16] Giovanni Boccacio (1313-78) native of Florence, Italy. He is best known as the author of the *Decameron*.

[17] The town of Amberg in Bavaria.

[18] '*Fessularum mons* (sayes he) *in Hetruria, Florentiae civitati imminens, lapides plumbarios habet; qui si excidantur, brevi temporis spatio, novis incrementis instaurantur; ut* (annexes my Author) *tradit Boccacius Certaldus, qui id comportissimum* [corrected to *compertissimum* in the *Errata*] *esse scribit. Nihil hoc novi est; sed de eadem Plinius, lib. 34. Hist. Natur. cap. 17. dudum prodidit, Inquiens, mirum in his solis plumbi metallis, quod derelicta fertilius reviviscunt. In plumbariis secundo Lapide ab Amberga dictis ad Asylum recrementa congesta in cumulos, exposita solibus pluviisque paucis annis, reddunt suum metallum cum fenore.*'

[19] Johann Gerhard (1598/99-1657) Professor of Practical Medicine at Tübingen. His *Decas quaestionum physico-chemicarum de metallis* of 1643 may have served Boyle as a source for his opinions on the growth of metals. See: Hiro Hirai and Hideyuki Yoshimoto, 'Anatomizing the Sceptical Chymist: Robert Boyle and the Secret of his Early Sources on the Growth of Metals', *Early Science and Medicine* 10, no.4 (2005): 453-477.

> finger's length. The witness to this is Dr. Schreterus, who in his own home often shows and gives to others items of this kind, of delightful and admirable appearance. Similarly sky-blue water was found at Anneberg, where silver was still in its primary state, which water was made to coagulate into masses of permanent and useful silver.'[20]

Carneades here is speaking of the growth of silver, which is quite an inert metal, and although it frequently occurs in the form of ores, it does occur native, as crystals having wiry or scale forms.[21] Some of these wiry growths, reaching about 10cm in length, could be described as being of finger length. The actual occurrence of silver can sometimes be in hydrothermal veins, and if these vent to the open air their water could well take on the sky-blue colour as reported in Gerhardus's account. The small amounts of silver formed in these veins would have a fine, more or less dendritic structure, and would indeed be pleasing in appearance. Of course the silver comes into being by virtue of geological activity; nevertheless it does seem to be growing from the water, in one sense, rather than out of the walls of the hydrothermal veins, as is actually the case.

[20] '*In valle* (sayes he) *Joachimaca* [corrected to *Joachimica* in the *Errata*] *argentum gramini* [corrected to *graminis* in the *Errata*] *modo & more e Lapidibus minerae velut e radice excrevisse digiti Longitudine, testis est Dr. Schreterus, qui ejusmodi venas aspectu jucundas & admirabiles Domi sua aliis saepe monstravit & Donavit. Item Aqua caerulea Inventa est Annebergae, ubi argentum erat adhuc in primo ente, quae coagulata redacta est in calcem fixi & boni argenti*.'

[21] A.L. Bishop, A.R. Woolley, and W.R. Hamilton eds., *Minerals, Rocks and Fossils* (London: George Philip, 1999), 16.

Carneades goes on to give 'two relations' (360.28) regarding the production of metals. The first of these he quotes from the Commentary of Johannes Valehius[22] upon the *Kleine Baur* (361.4-6) and goes on to relate how a workman whilst working at a 'Mine-Town' (361.8) close to Strasbourg came upon a 'mighty stone or Lump' (361.25-26) of 'pure fine Silver' (361.29-362.1) and 'according to the Dutch, [*sc*. German] account makes 500 pound weight of fine silver' (362.6-8). Valehius seems to believe that the 'Noble Metalline Spirits (Sulphureous and Mercurial)' (362.9-11) collected 'as in a close Chamber or Cellar' (362.15-16), and eventually formed this mass of silver. What Valehius seems to be giving here is an account of metal formation based on the Mercury-Sulphur Theory of the Generation of Metals.[23] What the workman actually seems to have discovered was a deposit of native silver (which if converted into a block of the metal would measure approximately 200 mm x 200 mm x 400 mm in size) and which occurred in a vein of silver ore.

Carneades then gives an account of metal formation given by '*Johannes* (not *Georgius*) *Agricola*'[24] (362.22-23) who, writing about what Poppius[25] 'has written of Antimony' (362.24). Carneades goes on to give this account as his relating that

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[22]This seems to have been Johann Grasshoff/Grasshof/Grasse (*c*.1560-1623) a Pomeranian jurist and alchemical writer. A commentary on the anonymous tract *Der kleine Bauer* is ascribed to him.

[23] Medieval alchemists adopted from their Islamic counterparts the theory that all metals were a synthesis of mercury and sulphur, whose union might achieve varying degrees of harmony. A perfectly harmonious marriage of the mother and father of metals might produce gold; all other metals were in varying degrees imperfect, corrupt and subject to corrosion.

[24] Johann Agricola (*c*. 1590-1643) distinguished German surgeon and physician, was a strong supporter of Paracelsus and of chemical remedies.

[25] Identified by Hirai and Yoshimoto (*q.v.*) as Johann Poppius, (1577-?) a German chemist who wrote on chemical medicine, and from whose *Chymische Medicin* (Frankfurt, 1617) Boyle's testimony is taken.

when he was 'among the *Hungarian* mines in the deep Groves' (362.25-26) he observed that there would often arise in them 'a warm Steam' (362.28) which fastened itself to the walls. When he came to look at it again after a couple of days, he 'discerned that it was all very fast, and glistering' (363.5-6). Having collected it and distilling it in a retort -'*per Retortam*' (363.7-8) - he obtained from it a 'fine Spirit' (363.8), and the miners informed him that this 'Steam or Damp [probably derived from *Dampf* (steam), as Boyle says that they retain the 'Dutch', *sc*. German, term]' (363.10) would 'at last have become a Metal, as Gold or Silver' (363.12-13).

Given that the 'warm steam' which fastened itself to the walls, and which in a couple of days was found to be 'glistering', and that all of this happened in relation to antimony, seems to indicate that the material observed on the walls was the mineral stibnite. This is a sulphide of antimony, and is the most common antimony ore. It is a soft, opaque lead-grey mineral which is sometimes tarnished and iridescent.[26] The 'warm steam' would simply have condensed on the walls, so that what was actually scraped off the walls by Agricola probably amounted to nothing more than some stibnite dispersed in water, and the 'fine spirit' that distilled over in the retort would simply have been water.

According to Healy, stibnite appears to have been known to Pliny, who gives a garbled account of the mineral:

[26] *Minerals, Rocks and Fossils,* 30.

> '*spumae lapis candidae nitentisque non tamen tralucentis; stimmi appellant, allii stibi*'.[27]

This description of a stone made of a white, shiny but not transparent froth is not unlike the 'glistering' mineral on the mine walls described by Agricola, and two of the names for this mineral given by Pliny are defined by Lewis and Short as: 'stibium, stibi, stimmi; antimony, a sulphuret of antimony'.[28]

As antimony also occurs native, in hydrothermal veins, often associated with silver or arsenic, and accompanied by stibnite,[29] it is quite possible that the condensation on the walls observed by Agricola was associated with a hydrothermal vein where antimony and silver deposits could have built up over time. Hence the reference to the condensate becoming a metal 'as gold or silver'.

Carneades draws some interesting conclusions on the formation of minerals and metals from the examples just quoted, the first is that the Paracelsian *tria prima* of 'Salt, and Sulphur, and Mercury' (363.26) are not required by nature in their production, the second is that 'two last relations' (363.28) *i.e.* on silver and antimony, seem to favour Aristotle's account 'who would have metals generated of certain *Halitus* or steams (363.29-364.1-2) over that of the chemists. Carneades' third conclusion is the most perceptive in that he draws on the evidence of those who have given the accounts on mineral and metal formation. He argues that when considered together these observations favour the explanation that the 'mineral

[27] J. F. Healy, *Pliny the Elder on Science and Technology* (Oxford: Oxford University Press, 1999), 338-339.
[28] Lewis and Short, *A Latin Dictionary*, repr. (Oxford: Clarendon Press, 1988), 1758.
[29] *Minerals, Rocks and Fossils*, 18.

Earths of those metalline steams' (364.4-5) contain 'some seminal rudiment' (364.7-8) or its equivalent which acts on matter – even earth – and by its 'plastick power' (364.9-10) converting it into a variety of metal ores. And Carneades links this process with the growth of plants in which his own experiments revealed that 'fair water' (364.14) acting on the 'seminal principles' (364.14-15), which he identifies with their seeds causing 'Mint, Pompions [pumpkins] and other vegetables' (364.15-16) to grow.

Carneades gives as his justification the regeneration of nitre (saltpetre or potassium nitrate) observed by the 'Boylers of Salt-Petre' (364.20-21), who understand that if the nitre is washed out of some 'Earth pregnant with Nitre' (364.23-24) the nitre will reform over time, and a heap of decaying organic matter will serve 'as a Perpetual Mine of Salt-Petre' (364.29-365.1). He explains the formation of nitre as due to 'the Seminal principle of Nitre latent in the Earth' (365.2-3) which gradually transforms nearby matter 'into a Nitrous Body' (365.4-5). He does acknowledge that 'some Volatile Nitre' (365.6) may be attracted 'out of the Air' (365.8), yet dismisses it as an unsatisfactory explanation because the centres of such heaps of organic matter 'lye so remote from the Air' (365.9-10), and for other, unstated, reasons.

Carneades then goes on to discuss the formation of 'Vitriol' (365.18) or iron sulphate, from 'a kind of mineral which abounds in that salt' (365.20), obviously the mineral pyrite (iron pyrites, or iron sulphide), which becomes clear when he speaks of marcasite, a little later in the text. He is here speaking of the formation of iron sulphate through the oxidisation of iron sulphide, which reaction occurs even when the iron sulphide is kept dry, though still in contact with the air. Carneades observes that the transformation into iron sulphate occurs throughout the entire thickness of the pieces of vitriol, and not just superficially. Allied to this is his own account in which he came upon 'a certain kind of Merkasite' (365.28) [marcasite is chemically identical to iron pyrites, but exists in a different crystal system] which in the space of a few hours 'even in my chamber' (366.1) began to turn into iron sulphate.

Carneades returns to his discussion of nitre, and makes another argument in which he states that nature has no need for salt, sulphur and mercury in order to produce metals and minerals, even if these products might be obtained from them through thermal decomposition. His argument hinges on his belief that ingredients which go into the production of a given material are not necessarily the same as those obtained through its decomposition. The example he cites is the decomposing and redintegration or restoration of nitre. He states that 'as nature made this Salt-Petre out of the once almost and[30] indorous Earth it was bred in' (366.5-8) rather than from 'a very stinking and corrosive Acid Liquor [nitric acid] and a sharp Alcalyzate Salt [potassium carbonate] to compound it of'[31] (366.8-10).

[30]Given as 'an' in the 1680 edition.

[31]In Boas's account of this experiment, Boyle performed his redintegration of nitre by burning saltpetre with charcoal and obtained 'fixed nitre' [potassium carbonate] an alkali, and 'spirit of nitre' [nitric acid] an acid, which could be recombined or redintegrated to give saltpetre, although he did not admit that the charcoal played any role in the formation of the 'fixed nitre' [potassium carbonate]. See: Marie Boas, *Robert Boyle and Seventeenth-Century Chemistry* (Cambridge: Cambridge University Press, 1958), 94, 217.

Carneades moves on to another consideration of the non-necessity for nature to have at her disposal salt, mercury and sulphur in the making of metals and minerals, by returning to the 'relations of our two German Chymists' [Johannes Valehius and Johannes Agricola] (366.20), which, to recap, Valehius's argument is that sulphurous and mercurial spirits collected as into a 'close' [secluded] (362.16) chamber or cellar and over time turned into a mass of native silver. The second account is that in which Johannes Agricola believes that 'a warm Steam' (362.28) which clung to the walls of the mines, would in time have become a metal.

Here Carneades is speaking of the production of metals from either sulphur and mercury or the Paracelsian's *tria prima* of sulphur, mercury and salt, but argues that the validity of either account 'cannot be convincingly prov'd' (366.21-22). He argues that the heat generated in a mine is not sufficient to cause these materials to react together, and gives as evidence his own experiments on distillation in which he notes how much heat is required to raise salt and mercury to the 'height of one foot' (366.29–367.1). He goes on to answer the objection that in lightening strikes 'sulphurous steams may ascend' (367.5-6) by invoking the sulphur-mercury theory on the formation of metals, in saying that the 'sulphur of silver' (367.9) is a 'fixt [unreactive] Sulphur' (367.10).

Then Carneades dismisses what has been said on the grounds that it was no more than some 'hints' (367.14) on the origin of metals. His real object seems to be to discuss the underlying validity of his arguments by comparison with those of the Aristotelians.

Carneades makes a further argument on the composition of minerals. He argues that even if 'either Sulphur or Mercury' (368.28) were to be obtained from 'all sorts of Minerals' (368.29), these would be compound, rather than elementary, materials. What Carneades means here is unclear: what he seems to be saying is that the mercury of sulphur drawn from such a mineral through decomposition would not be in the pure state but rather would be compound. The 'other occasion' (369.3) on which he told us this is not here specified.

Carneades goes on to speak of two distinct types of quicksilver or mercury, the first of which is 'common, or drawn from Mineral Bodies' (369.6-7). 'Common' here seems to mean the silver-grey, dense metal (the element Hg) and which is obtained by smelting a mercury ore. This metallic liquid Carneades contrasts with the 'immature and fugitive substance' (369.9-10) which is found in living things, and is non-metallic in nature. (It is, in fact, the liquid fraction obtained in the distillation of organic materials). This latter mercury Carneades further contrasts with that which is present in a true mercury compound, and he quotes as an example 'Native Vermillion' (369.25) (the mercury ore cinnabar, mercuric sulphide) where the mercury and sulphur are 'exquisitely blended' (369.27) not just with one another but also with the impurities which form a constituent part of the ore. The mercury present in this compound retains its own identity: it is 'a perfect Body of its own kind' (369.18-19). It is compounded with the other substances of which the metal (or in this particular case, mineral) consists, at the most finely divided form possible – '*per minima*' (369.22).

All of this presupposes that the mercury was not obtained by the action of the fire on the metal ore, but rather, was 'pre-existent in it' (369.15-16). Carneades notes that 'part of the Quicksilver [mercury], and of the Sulphur, may be easily enough obtained' (370.3-4), meaning that cinnabar may be decomposed into its constituent mercury and sulphur simply by heating it in a current of air.

Carneades goes on to give a further example of two materials intimately compounded – silver and lead occurring in the same ore body – yet he argues that the former can be separated from the latter, although ''tis extreamly difficult' (370.7).[32] Carneades gives a third example: that of 'native Vitriol [iron sulphate]'(370.9-10) in which the 'Metalline Corpuscles are by skill and industry separated from the saline ones' (370.9-12), although the compound itself is 'reckon'd among Salts' (370.14-15). What he seems to be referring to here is the fact that when heated to red heat, iron sulphate decomposes to give ferric oxide, sulphur dioxide and sulphur trioxide. The ferric oxide may, in turn, be smelted to yield metallic iron, which is obviously quite distinct from the original iron sulphate.

[32] The chief ore of lead, *galena* (lead sulphide) usually contains 0.01 – 0.1% of silver. If lead and silver are mixed, the lead can be removed through *cupellation*, in which the lead is oxidised by heating.

Carneades further observes that he has never seen either earth or water separated from gold, silver or other metals which allows him to 'retort [turn back] the argument upon my Adversaries' (370.20-21) that there are bodies in which these two materials are not present. This is a contradiction of the Aristotelian belief that all mixed bodies consist of earth, air, fire and water. Carneades wishes that Eleutherius would remember the foregoing 'against Anon' (370.29), probably meaning again in a short while.

Carneades counters the argument that the water pre-existing in metal ores is driven off by the heat applied to the ore during the smelting operation, by giving some examples of gold and silver occurring native, *i.e.* in uncombined form, rather than as an ore (which is usually the case with most metals, including silver). He quotes from Josephus Acosta[33] who describes the finding of pieces of silver 'very fine and pure like to small round roots' (371.16-17) and of 'Gold in grains' (371.20) which he says they find whole, without mixture of any other metal, and requiring no 'melting or refining in the fire' (371.24-25). In the case of silver, Carneades is here probably referring to the occurrence of small pieces of native silver, in the form of dendritic growths, and of the grains and irregular rounded masses or nuggets of native gold.

Carneades gives an example from the '*Hungarian Mines*' (371.28) of pieces of gold, about the size of a 'humane Finger' (372.3) growing in the ore, as though they had

[33] José de Acosta (1539/40-1600) Spanish Jesuit theologian and missionary to the New World. Chiefly known for his *Historia natural y moral de las Indias,* in which he wrote of the natural history as well as the physical geography of Mexico and Peru.

been 'parts and Branches of Trees' (372.4-5). He seems to be referring here to the occurrence of native gold in dendritic forms. He goes on to describe a stone looking like a 'kind of sparr' (372.10-11) in which pieces of gold grew, some of which seemed to be 'about the Bigness of pease' (372.14-15). Gold occurs in small amounts in hydrothermal veins, often in association with quartz. What Carneades seems to be referring to here is an example of a piece of quartz on which some small gold nuggets had grown. He goes on to speak again of Acosta who mentions 'morsels of Native and pure Gold' (379.19-20) some of them quite heavy – an obvious reference to some large gold nuggets. Interestingly, Carneades describes having seen 'a Lump of Oar' (372.23-24) and which seems to have had dendritic growth of a pure metal other than gold, perhaps native silver or copper, growing on its 'stony part' (372.25).

Carneades goes on to discuss the thermal decomposition of vegetables and acknowledges that although five different substances may be obtained, nevertheless he believes that these are not 'Elements in the Notion above Explain'd' (373.15-16). He denies that 'Elements or Principles' (373.20-21) are intrinsically different from each other, but only differ 'in consistence' (373.29), and makes a comparison between them and 'Running Mercury' (373.29) in its original state and when it is 'congeal'd by the Vapor of Lead' (174 [374].1), (a reference to the formation of an amalgam of mercury and lead) as well as differences caused by some 'very few other accidents'[34] (174 [374].2-3).

Carneades makes a second argument by saying that means such as 'Fire and other Agents' (174 [374].6-7) can bring about the separation of substances into their more finely divided and primary components, but thereafter 'connect them after a new manner' (174 [374].9-10), together with whatever accidents are required for them to be counted as 'Salt, or Sulphur, or Earth' (174 [374].12-13). He goes on to declare his 'apprehensions' (174 [374].14) regarding the composition of material things. He declares his dissatisfaction with both the Aristotelians and the Paracelsians, then goes on to deny that he is either an Epicurean[35] or an Helmontian, and then relates how little of '*Lucretius*'[36] (375.1-2) he has read.

Carneades in musing on the origin of things, considers that an 'Architectonick Principle' (375.20) [*i.e.* a principle having the function of superintendence and control] must act on the 'Great Mass of Matter' (375.17) and transform it into the many products, animate and inanimate, which constitute the created world. He goes on to restate his fundamental principles of the created world as '*Matter, Motion* and *Rest*' (376.14-15), being careful to stipulate that this refers to 'the world as it now is' (376.13-14) as he believes that motion is not inherent to matter, but was added to it

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[34] The term 'accident' in this context stems from Aristotle. An accident is a quality which is not essential to the kind of thing (or in later philosophers, to the individual) in question. For example, 'being musical' is accidental to being human, 'being rational' and 'being an animal' are not.
[35] Epicurus (342/41-271/70 BCE) was a Greek philosopher. A student of the writings of Democritus (who together with Leucippus was the prime exponent of the philosophy known as atomism). Epicurus had considerable influence, not least for his account of atomism.
[36] Lucretius (98-55 BCE) was a Roman poet who embraced the philosophy of Epicurus and expounded it in a celebrated poem *De rerum natura* (*On the Nature of Things*).

by the Creator, after matter itself had been created. When it comes to deriving various qualities of bodies, 'Colours, Odours ... and Solidity' (376.27-28) [so called secondary qualities] Carneades can only 'declare in general' (376.24-25) how they can be derived, but is confident in deducing two of the Epicurean principles – magnitude and figure – from his own two principles of 'Matter and Motion' (377.6) although he does not deduce Epicurus' weight from them. He does not count 'the *Aristotelian Privation*'[37] (377.13-14) as a principle but as an 'Antecedent or a *Terminus a quo*'[38] (377.17).

Interestingly Carneades gives two reasons why he includes rest as one of his principles, the first is that it enables a body 'both to continue in a State of Rest till some external force put it out of that state' (378.1-3), 'and to concur to the production of divers Changes in the bodies that hit against it' (378.3-5). These two phrases bear a striking resemblance to contemporary expressions of Newtown's first and second laws of motion, respectively,[39] which were not published until 1687, almost thirty years after Boyle first published his *Sceptical Chemist* in 1661.

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[37] According to Aristotle, form and privation act as a pair of opposites between which change takes place. For example, hot and cold, one of which represents the 'form' and the other the 'privation'. Change in general is represented in terms of a progression from the privation to the form or *vice versa*.

[38] *Terminus a quo* = the earliest possible starting point.

[39] Newton's first and second (of three) laws of motion are: (1) 'Every body preserves in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by impressed forces.' (2) 'Change of motion (*i.e.* rate of change in momentum) is proportional to the impressed force and takes place in the direction in which that force is impressed' in: A. Wolf, *A History of Science, Technology and Philosophy in the 16th and 17th Centuries* (London: George Allen & Unwin, 1935), 155.

Carneades reiterates his fundamental principles as matter, motion or rest, yet he wishes also to identify the 'Principles of Particular bodies' (378.19-20) and it does seem here that he is drawn to the Aristotelian concept of physical bodies being possessed of matter and '*Forme*' (379.19). He is careful to draw a distinction between Aristotle himself and those who adopted his understanding of material bodies in late medieval times (and indeed later) the so called Scholastic Philosophers, whose concept of '*Substantial Forme*' (379.23) is 'Un-intelligible' (379.25) to 'many intelligent men' (379.24).

Carneades as sceptic is careful to assert his independence of Epicurus, (a proponent of an atomic theory of matter) Aristotle, (among other things, as an opponent of the atomic theory) the chemists, as proponents of certain unacceptable views on material change, and van Helmont, for ascribing 'almost all things' (380.27) to 'their determinate Seeds' (380.28-29). His overall intention seems to be to vindicate an understanding of nature in which 'seminal principles' (381.4-5) are the originators of many natural bodies – including 'some *M*etals and *M*inerals' (381.3) – but that other causes also, such as inanimate qualities acting on matter at its most fundamental level, and human manipulation of matter, may account for the production of materials. He continues with this theme by saying that merely by rearranging micro-constituents 'without addition of new ingredients' (381.20-21) change may be effected in material both by human and natural means.

Carneades quotes the example of 'Sugar of Lead' (383 [382].5) [lead acetate] (which, despite its sweetness, is highly toxic) and argues that as this substance is made by combining a derivative of vinegar with an 'insipid Metal', (383 [382].6) [lead], then the only way in which these starting materials can produce a sweet-tasting produce is for them to undergo a re-arrangement of their parts at the ultimate level of subdivision such that the altered product which emerges is also radically different in its fine structure from the original reactants, and has acquired a property (sweetness) not possessed by either of the starting materials.

Carneades continues to drive home his argument against the *tria prima* of the Paracelsians by reiterating his belief that fire may be an active agent of chemical transformation, which is as effective in producing new materials during the combustion process as in decomposing them. He reasserts his scepticism towards the *tria prima* as the final stage in the thermal resolution of organic materials by stating that these are not actually primary bodies but are 'yet compounded' (383 [382].24-25), and may, in fact, be produced out of water.

He then goes on to make an argument that compound bodies or 'Heterogeneities' (382 [383].4-5) do not pre-exist in organic bodies as they are beginning to grow or form, (but in the case of a 'Concrete [inorganic material]' (382 [383].8) they are 'in-existent [inherent]' (382 [383].8) and when the growing body is analysed at that time, 'when the Chymists first goes about to resolve it' (382 [383].9-10). Carneades continues that the supposed bodies that emerge during the decomposition process cannot be held emphatically by him to be spirit which fails to support combustion because it may be 'pretended to be' (382 [383].12-13) no more than a mixture of 'Phlegme and Salt' (382 [383].13-14). He continues with van Helmont's account of decomposition in which 'the Oyle or Sulphur' (382 [383].14) of vegetables or animals [*i.e*. vegetable oil or animal fats] are capable of reacting with 'Lixiviate Salts [alkalis] into Sope' (382 [383].16-17).[40] Van Helmont can then reverse this reaction by repeated distillation from a '*Caput Mortuum* of Chalk [calcium carbonate]' (382 [383].18-19) to regenerate water.

Continuing with his reference to van Helmont, Carneades seems to be hinting at an understanding of chemical reactions as involving the rearranging of the micro-constituents of materials, under the agency of fire, causing one set of reactants to transform into another set of reaction products. In this way the 'saline substance' (382 [383].20) (probably in this case referring to a solid product) which can be separated from 'mixt bodies' (382 [383].22) may be brought about by the fire acting on the materials in question, causing a new saline product to be formed which is separable from the original reactants.

Continuing with his theme of saline materials Carneades says that van Helmont claimed to know 'a way to reduce all stones into a meer [pure] Salt of equal weight with the stone whence it was produc'd' (384.2-5). Van Helmont seems to be claiming that he can convert all stones into a salt, and nothing else. The fact that

[40] This is a reference to the so called 'saponification reaction' in which an animal fat or vegetable oil is reacted with sodium or potassium hydroxide to give a soap.

Carneades mentions 'a way' (384.2-3) hints that it is neither his *alkahest*, or universal solvent, nor fire, which would be the standard means by which he would be expected to set about his analysing of bodies, but is, in fact, a process distinct from these. It could, of course, involve a combination of the two processes – perhaps first of all heating it, and then attacking it with a solvent. Whatever process was employed, there should be no weight change occurring between the initial weight of the stone and the final weight of the product. Nor is there to be 'the least either Sulphur or Mercury' (384.6). Carneades adds that this 'asseveration' [emphatic assertion] (384.7) would seem more credible if he 'durst' [dared] (384.9) make known all that he knows on the subject, perhaps an indication that he himself has direct experimental knowledge in support of van Helmont's claim.

Carneades makes the argument that the sulphur and mercury which the chemists obtain from 'compound bodies by the fire' (384.14) are not always pre-existent in those bodies but may be products of the combustion process by which they are treated. He states that if these bodies instead had been acted upon by 'the Agents employ'd by *Helmont*' (384.17-18) no sulphur or mercury would have been produced but rather a 'Salt' (384.24) would have been left as the final product of reaction in the form of a solid incombustible residue.

Eleutherius then makes an intervention in which he argues that whatever about materials of inorganic nature, things of organic origin – plants and animals – when subjected to destructive distillation, yield as products an aqueous fraction and a solid, charred residue, the '*Caput Mortuum* or Earth' (385.7-8). This he argues, adds support to the belief that earth and water are 'Elementary Ingredients' (385.1) of animal and mineral bodies, though not of minerals.

Carneades agrees that it is easier to reject the *tria prima* as constituting elements than earth and water, then adds enigmatically 'but 'tis not every difficult thing that is impossible' (385.15-16). What he seems to mean is that although it is more plausible that water and earth are the only two elements rather than the *tria prima* of mercury, salt and sulphur, both propositions are *possible*.

Carneades goes on to make an argument in which he states his objection to water being considered as produced in the decomposition of bodies, which centres on the aqueous fraction obtained by the decomposition of what are probably organic materials (although he does not specifically state this) by saying that this fraction does not conform to what would normally be identified as water. Apart from liquidity, water has as its 'chief Qualities' (385.17) that it is 'insipid and inodorous' (385.20). He posits that these terms cannot be applied to what the 'Chymists call Phlegme' (385.23) which is completely devoid of 'Taste and Smell' (385.25).

Carneades offers a possible objection from Eleutherius then counters it, to do with the nature of fluidity. He posits that in the decomposition of organic bodies by fire 'since the whole Body is Liquid' (385.27) it is reasonable to suppose that the bulk of the body is 'But Elementary Water faintly imbu'd with some of the Saline or

Sulphureous parts of the same Concrete' (385.28-386.1) which remain as residues following the separation process. Carneades answers this argument by explaining the nature of fluidity as consisting of a body in the fluid state, having been divided 'into parts small enough' (386.10) and that these can be put into such a motion as to allow them to 'glide' (386.12) over one another in different directions. He goes on to state that a dry, solid material, without any liquid ingredient present in it can yet be acted upon by the fire or other agent resulting in 'a Comminution [reduction or breaking up into small fragments] of its parts' (386.17-18) so as to 'turn a great portion of them into liquor' (386.19-20).

Carneades cites an experiment which is illustrative of the 'nature of Salts' (386.23-24) carried out by 'our friend here present' (386.21-22) [Boyle himself, still present at the discussion as a silent note-taker], and goes on to describe how sea salt if heated in the fire 'to free it from the aqueous parts' (386.25-26) in the presence of 'Burnt Clay, or any other' (386.27-28) present as inert substrate or '*Caput Mortuum*' (386.28) a 'good part of the Salt in the form of a Liquor' (387.1-2) will distil over. And in order to prove that the distillate was indeed sea salt – although now in liquid form, due to its corpuscles being so reduced in size and altered in shape as to 'be capable of the forme of a Fluid Body (387.7-8) – Boyle added to this liquid distillate 'a due proportion of the spirit (or salt and Phlegme) of Urine' [probably ammonium hydroxide] (387.10-11).

On heating this solution he obtained another chemical compound having the taste, smell and ease of sublimation of 'common Salt *Armoniack*' [ammonium chloride] (387.15-16), which is made up of 'grosse and undistill'd sea salt [principally sodium chloride] united with the salts of Urine and of Soot' [both of these are ammonium hydroxide] (387.17-18). As a demonstration that the corpuscles produced in this reaction 'retain their several Natures in this Concrete' (387.22-23), Boyle mixed this with some 'Salt of Tartar' [potassium carbonate] (387.24), and upon distillation obtained the 'spirit of Urine [ammonium hydroxide] in a liquid form by its self, the sea salt [sodium chloride] staying behind with the Salt of Tartar' [potassium carbonate] (387.26-28).

Carneades takes the above set of experiments as evidence that 'dry Bodies' (387.29) may be acted upon by fire, and have their corpuscles reworked by the heat, reducing them in size, and 'brought into a new state' (388.4-5), to such effect as to reduce the once solid material to the liquid state but 'without any separation of Elements' (388.1-2).

The process Carneades is speaking of – the conversion of certain salts into a liquid – is now understood to be due to hygroscopicity, whereby water is absorbed from the atmosphere until eventually a concentrated solution of the salt may form. However, in not understanding hygroscopicity as the cause of the apparent liquefaction of some salts, Carneades sought to explain the phenomenon in terms of the conversion of the salt itself into a liquid through a change in its micro-structure, causing the dry, solid salt to be transformed into a liquid. He believed that if the corpuscles of the salt can be reduced in size and increased in smoothness, then they would constitute a liquid.

Carneades continues in this vein by answering a further possible objection: that 'the Phlegme of mixt bodies must be reputed water' (388.6-7) because the weak taste of the phlegm needs only a small proportion of salt present in it to impart a salty taste to it (thereby making it seem plausible that the phlegm is nothing more than faintly saline water). He counters this argument by giving an account of the observed behaviour of 'common Salt' [sodium chloride] and divers other bodies' (388.10-11). Even if these salts are distilled to dryness in closed vessels, they will each, nevertheless, yield 'pretty store of a Liquor' (388.13-14) in which 'Saline Corpuscles abound' (388.15). That there is phlegm present is easily demonstrated by 'coagulating the Saline Corpuscles with any convenient Body' (388.18-19).

Curiously Carneades has described all of the stages in the behaviour of a hygroscopic salt: the salt, even though carefully dried, picks up moisture from the air and begins to form a solution of the salt. That this is indeed an aqueous solution of a salt is understood by Carneades who finds 'a large proportion of Phlegme' (388.16-17) present by 'coagulating the Saline Corpuscles with any convenient Body' (388.18-19). He goes on to give an example of this process by relating how 'our Friend [Boyle himself] coagulated part of the Spirit of Salt [hydrochloric acid] with Spirit of Urine' [ammonia] (388.20-21). What happened here was that Boyle reacted hydrochloric acid with ammonia to form ammonium chloride and water. The ammonium chloride could then be recovered by evaporating off the water.

Carneades then gives an example from his own experience by saying that he had on many occasions separated 'a salt from Oyle of Vitriol' [sulphuric acid] it self' (388.22-23), noting that this is a 'very ponderous liquid and drawn from a Saline Body'[41] (388.23-25) by boiling it with 'a just [appropriate] quantity of Mercury' (388.25-26) and then washing the 'newly coagulated salt' (388.27) thus produced with water.

What Carneades is describing here is the preparation of mercuric sulphate by the reaction of sulphuric acid with mercury. Having obtained the mercuric sulphate, washed and dried it, he ponders how we can account for 'this plenty of aqueous Substance afforded us by the Distillation of such bodies' (388.29-389.1-2). Of course what Carneades does not understand is that the salt he has just prepared, and dried, being very hygroscopic, begins to absorb moisture from the atmosphere, and as it does so another chemical change occurs in the salt – it begins to hydrolyse to form the sparingly soluble, crystalline yellow basic mercuric sulphate.[42] This is what Carneades seems to be referring to when he speaks of the 'change of Quicksilver [mercury] into Water' (389.15-16) and 'that Water having but a very faint tast' (389.16-17). This may represent his description of the gradual formation

[41] Sulphuric acid is an oily, viscous liquid, with a relative density of 1.84 – making it almost twice as dense as water.
[42] Hydrolysis is a chemical reaction in which a chemical compound reacts with water to form other compounds.

of a solution containing a small amount of basic mercuric sulphate, produced by the hydrolysis of the newly prepared mercuric sulphate.

Carneades takes the transformations of mercuric sulphate as evidence that not only vegetable or animal bodies, but ‘even a metalline body’ (389.20-21) may by a ‘simple operation of the fire be turn’d in great part into Water’ (389.23-24). He finishes his argument by stating that ‘those I dispute with’ (389.25) are unable to obtain any aqueous product from gold or silver. He concludes that although a metallic body may turn into water, as he has just described, this water was not pre-existent in the mercury which he converted into mercuric sulphate. His overall conclusion being that water ‘it self is not an Universal and pre-existent Ingredient of Mixt Bodies’ (389.29-390.1-2).

He then considers a favourite discussion point of his thinking on matter: the question of the universal solvent or *Alkahest*, and its ‘wonderful Effects’ (390.5-6), which van Helmont claimed could convert all materials into pure water. He acknowledges that van Helmont’s ‘Affirmations conclude strongly against the Vulgar Chymists’ (390.11-13), believing as he does that the ultimate principles of reduction of bodies are not ‘Permanent and indestructible’ (390.17) since they can be further reduced into ‘Insipid Phlegme’ (390.19). However, Carneades’ objection is that this phlegm may itself not be ‘Meer Water’ (390.23). And, of course, we may not see this as a difficulty, as it is now quite an easy matter to identify chemical compounds by certain characteristic physical properties, but this was not the case in

Boyle's day. Carneades argues that van Helmont believes that it is the quality of being 'insipid' (390.26) that identifies this liquid as water, but that taste in itself does not disclose the identity of a chemical product.

Carneades makes the argument of 'Sapour being an Accident or an Affection of matter' (390.26-27), that is to say taste is not a primary quality of matter, as size, shape and weight are, but rather a property that is attributed to materials by the person experiencing it. It is possible to measure the weight or physical dimensions of a body using techniques agreed on by the generality of observers, but not so with properties such as taste which is a subjective property whose evaluation varies from individual to individual. Having established this point Carneades then argues that the micro-constituents of materials, by their 'extream Littleness' (391.3), 'slenderness or by their Figure' (391.3-4) are simply unable to act upon the 'Organs of Tast' (391.7-8).

Carneades then goes on to make a connection between the inability of the taste buds to truly taste a material which is, on account of its physical disposition, unable to affect them (and thereby fails to be registered by the sense of taste for what it is), with another case. He says that if other bodies can be mistaken for water because of their taste, then other materials too may be capable of appearing to be something they are not. Such a material can 'Disclose it Self to be of a Nature, farr enough from Elementary' (391.11-12), even though to the senses, or at least to the sense of taste, it seems to be nothing other than bland, insipid water, rather than the actual non-aqueous material it in fact is.

He provides another example of how the real nature of something can be disguised – this time through a process of attenuation. In the case of 'Silke dyed Red or of any other Colour' (391.12-13) Carneades makes the argument that the colour is only apparent when several fibres of the dyed fabric are placed together in bulk form. When only a 'very few' (391.16) threads are viewed the colour is 'much fainter' (391.18) than before. When only an individual fibre is viewed it is difficult 'to discern any Colour at all' (391.20-21). Carneades gives another example of how the taste of a substance is not a true indicator of its real identity, by drawing attention to the fact that the finest quality olive oil is 'almost tasteless' (391.25-26) even though it is not at all aqueous in nature.

He then reverts to talking about mercury and speaks of an account of '*Lully*'[43] (391.29) of the liquor into which 'Mercury might be Transmuted' (392.1-2) which has a 'very Languid, if any Tast' (392.2-3), then adds a rather cryptic note by saying that its 'Operations' (392.4) are 'very peculiar' (392.5). Carneades continues that mercury itself is 'Tastless' (392.10) even though it can 'get into the Pores' (392.7) of gold which, because of its high density, is the 'Closest and compactest of Bodies' (392.8-9). He is here referring to the capacity of mercury to form an amalgam, or alloy, with gold.

[43] Ramon Lull/Llull (1232-1315/16) Catalan or Majorcean philosopher and Christian missionary to the Moors, to whom a number of works on alchemy have been attributed.

Despite mercury's tastelessness Carneades quotes van Helmont's assertion that 'Fair water' (392.11) which has been in contact with 'a little Quantity of Quicksilver [mercury]' (392.11-12) for some time, has the ability 'to destroy wormes in humane Bodies' (392.15-16). What is implied in this claim of van Helmont is that mercury left in contact with water will eventually form a toxic water soluble mercury compound. This claim is not easy to validate as mercury does react with some acids – such as dilute nitric acid – though not with water. It may be that the metal itself contains a water soluble mercury compound as an impurity, and it is this which dissolves in the water and serves to account for the reported properties of the mercury-laced water, which same product may have made an effective 'innocent [harmless or innocuous]' (392.21) face wash.

Carneades wishing to 'conclude my Discourse' (392.24-25) goes on to speak of 'waters or Liquors' (392.25-26) and how the consumption of alcoholic drinks may dull the palate and render it incapable of distinguishing the difference in taste between different samples of plain water, and that they are not 'all alike insipid' (393.17). He goes on to make a second argument saying that the fire may cause the corpuscles constituting a body to be 'dissipated' (393.20-21), presumably because they become embrittled by the heat and break up into smaller fragments of matter. Alternatively the corpuscles may have their 'figures so altered' (393.22-23), which seems to mean that the heat of the fire causes them to become plastic and adopt a new shape. A third option is that the corpuscles may 'by associations with one another' (393.23-24) be converted into agglomerations which, due to their 'Size and Shape' (393.25) are unable to register a sensation of taste on the tongue.

Having offered his speculations to the reader on how changes to the physical attributes of the corpuscles might cause a considerable modification to the taste of the materials these particular corpuscles constitute, Carneades goes on to offer experimental evidence in support of his case. He does so by pointing out how the 'sharpest spirit of Vinager' (394.1) 'is incomparably less thoroughly Tasted' (394.5) through dissolving 'corall' (394.2). Of course, what happens is that coral, which consists mainly of calcium carbonate, when dissolved in vinegar (a dilute solution of acetic acid), water, carbon dioxide and calcium acetate are formed, all of which have a much blander taste than vinegar.

Carneades then describes the stages in the reaction of mercury to form its chlorides. In the preparation of 'common sublimate [mercurous chloride]' (394.9-10) the 'Acid Salts' (394.7-8) employed in its preparation, as well as the 'Corrosive Sublimate' (394.12-13) [mercuric chloride] when wetted with water, are sharp and corrosive.[44] Carneades then describes how this 'Corrosive Sublimate being twice or thrice re-sublimed with a full proportion of insipid Quicksilver [mercury]' (394.12-15) reacts to form '*Mercurius Dulcis* [mercurous chloride]' (394.17-18), the sweetness of which he explains by the sharpness of the corrosive sublimate being eliminated

[44] The 'acid salts' referred to here may refer to the sulphuric acid which can be reacted with mercury and the liquor evaporated to dryness. The reaction product is then mixed with an equal weight of sodium chloride and sublimed to form mercuric chloride (corrosive sublimate) and sodium sulphate. See also: Partington, *General and Inorganic Chemistry* (London: Macmillan, 1958), 399.

through reaction with the 'Mercurial Corpuscles' (394.21) leading to the new compound's being considered as 'insipid' (394.23). And it is indeed the case that corrosive sublimate or mercuric chloride is highly toxic, much more so than *mercurius dulcis*, calomel or mercurous chloride, which is far less toxic, and has found use medicinally as a purgative.

Having completed his arguments on why he rejects 'Elementary water for a constant Ingredient of Mixt Bodies' (394.26-27) Carneades goes on to give his reasons for rejecting earth.

His first argument is that 'Many Substances' (325.2) considered as earth by chemists simply because they are 'Dry, and Heavy, and Fixt' (395.4), may be far removed from 'an Elementary Nature' (395.5-6). He begins by citing the example concerning the 'Dead Earth of things' (395.9-10), specifically the copper to be obtained from the '*Caput Mortuum* [inert residue] of Vitriol [here probably copper sulphate]' (395.11-12).[45] He quotes an 'Experiment made by *Johannes Agricola*' (395.14-15)[46] 'upon the *Terra Damnata* [inert residue] of Brimstone [sulphur]' (395.15-16). What he may be speaking about is a material consisting of some native sulphur which has a copper ore associated with it. He first of all 'made an Oyle of Sulphur' (395.18) apparently by placing the mixture of minerals in linseed oil to dissolve out

[45] What Carneades may be referring to here is the decomposition of copper sulphate at 736^{o}C to give cupric oxide and sulphur trioxide. Cupric oxide when heated below red heat with carbon is reduced to the metal. See: Partington, *General and Inorganic Chemistry*, 530, 535.

[46] Johannes/Johann Agricola (*c*.1590 – 1643) distinguished German surgeon and physician, who was a strong supporter of Paracelsus and of chemical remedies.

the sulphur [See 396.6]. He then 'reverberated'[47] (395.19) the remaining '*Faeces*' [the solid mineral residue]' (395.19), which he later put into a 'well luted [sealed] up'(395.21) wind oven, intending 'to calcine [oxidise]' (395.23) them to a 'perfect Whiteness' (395.24). Instead, he found a grey reside on top of a 'fine Red *Regulus* [red metal]' (395.29). This red metal most likely was the copper deposited when the mineral had been reduced to the metal, through being in contact with carbon left as a residue, when the linseed oil clinging to the pieces of mineral decomposed when heated in a limited air supply. Whatever gas was generated in the process could simply have escaped through the pores of the pot.

That the '*Regulus*' (396.6) spoken of was copper there can be little doubt. It was 'heavy and malleable almost as lead'[48] and a goldsmith identified it as the 'Fairest copper' (396.10). And as the reported yield of copper was six ounces out of one pound of 'Ashes or *Faeces*' (396.14-15), this would indicate that the copper had indeed been smelted out of a larger amount of copper ore.

What is, perhaps, most interesting from this account is the conclusion that Carneades draws from it, namely that as it took a long time for the copper to become apparent, it may be that the same is true of other mineral residues. He says that 'divers other Residences of Bodies' (396.20-21) present in 'the Terrestrial *Faeces* of Things' (396.22-23) may easily be discarded as dead, spent earth, as the chemical processes are completed, but in fact if they were subjected to careful analysis they could well

[47] In a reverberatory furnace the fuel does not come into direct contact with the material being heated.
[48] Copper, relative density 8.92, is almost as heavy as lead, at 11.35, and, as smelted, is a malleable metal.

be shown to contain other bodies, and be quite distinct from 'Elementary Earth' (396.28-29).

Carneades then takes to task the 'common Chymists' (397.1-2) for rejecting as dregs or waste, things such as 'the *Caput Mortuum* [inert residue] of Verdegrease [basic copper hydrate]' (397.4) which he says can be reduced to the metal by the use of 'strong fires and convenient Additaments' (397.6-7), he himself having prepared a 'certain Flux Powder' (397.9), obtained the metal from it.

Carneades here seems to have reduced verdegris to the metal by means of a suitable reducing agent of his own making, acting along with a source of carbon, such as charcoal.

Carneades then goes on to speak of 'Venetian Tackl' (397.13) [corrected to Talck in Boyle's *Errata* on p. 442] in a fire at least as hot as that of a 'glass Furnace' (397.14-15) which seems to have been largely unaffected by the heat. Talc as an inert mineral substance would not undergo any oxidisation or other chemical change at the temperature at which glass would be molten – about 500^{o}C.

He then goes on to speak of an '*American* Mineral Earth' (397.24) which when given to 'Publick Say-[assay] Masters' (397.29), that is, to the assayists who can test a mineral for its metal content. And as they were unable either to melt it or reduce it to an ash, the 'Relator' (398.3) tried it with a 'peculiar Flux' (398.5) and obtained from it 'neer a third part of pure Gold' (398.6), illustrating how incorrect judgements can be made in not taking sufficient time in analysing minerals. Assuming that this account is reliable, one can only conclude that the original mineral was a gold compound which was reduced to the metal by the use of an appropriate choice of reducing agents and fire.

Carneades then makes a comparison between the separation of bodies by the fire and that effected by 'other Agents' (398.18). In the case of fire the residue left by the combustion process may be so constituted as to result from particles separated out which may come together so as to form 'Corpuscles too heavy for the Fire to carry away' (398.15-16), and which constitute 'Ashes or Earth' (398.18). A further consideration is that 'other Agents' (398.18) may resolve materials into products so completely that only fine-particled products are obtained without any '*Caput mortuum* [inert residue], or dry and heavy Body' (398.21-22).

Carneades goes on to remind the reader of how van Helmont told us that with his 'great Dissolvant' (398.24) [his famous *alkahest* or universal solvent] he could divide 'a Coal' (398.24) into two liquids of the same total weight as the coal 'without any dry or fixt Residence at all' (398.26-27). What Carneades seems to mean is that van Helmont was able to react coal (probably) with perhaps a reagent such as nitric acid and obtain as much of two volatile liquid fractions as there was of coal (by weight), without any solid residue being left.

He then returns to another favourite theme, that of how bodies come to be decomposed into their constituent parts, as he believes that agents other than fire are capable of breaking down compound bodies. He says that he cannot see why other agents should break down bodies in the same way as fire does, or indeed resolve them into the same number, or of the same kind, of decomposition products as does thermal analysis. Other agents may divide bodies into a different set of simpler bodies 'both for nature and Number, as the Fire dissipates them into' (399.4-5). In addition to agents of decomposition giving rise to a set of decomposition products, motion plays its part in accounting for their variety, as it is 'their Fitness and Unfitness to be easily put into Motion' (399.8-9) that distinguished one product from another as much as 'do some of the Chymical principles' (399.12). What Carneades seems to have in mind here is that the properties of chemical substances derive from both the nature of the matter constituting them and a set of qualities derived from its motion. He may be thinking here of properties such as volatility, viscosity, and perhaps even boiling point, which derive largely from a body's being in a liquid state and so may be accounted for as much by the motion of the constituent particles as their physical attributes.

He makes a clever analogy between the division of wood into smaller units differing from one another, according to how the wood is worked using differing wood-working tools, and the reduction of matter itself into corpuscles depending on the agents employed to effect the reduction. He goes on to list the various tools and the types of levels of subdivision into which wood can be reduced.

Carneades then describes the behaviour of ‘Sulphur and Salt of Tartar [potassium carbonate] well melted and incorporated together’ (400.11-13). He notes that when treated with ‘pure spirit of wine [alcohol]’ (400.13) the two ingredients are separated by dissolving the sulphur though leaving ‘the Alcalizate Parts [potassium carbonate]’ (400.15) unaffected. Sulphur dissolves in alcohol, though not in water, whereas water dissolves potassium carbonate but not sulphur. Wine, as a dilute solution of alcohol, dissolves neither material: they simply form a mixture which is deposited at the bottom of the reaction vessel as ‘Corpuscles consisting of both Alcalizate and Sulphurous Parts united’ (400.19-21).

Carneades correctly explains the behaviour of the wine by attributing it as ‘probably upon the score of its copious Phlegme [water]’ (400.17-18). He goes on to say that if it be objected, that this is but a Factitious Concrete;’ (400.21-23) that is, an artificially prepared material, he replies that he employs it as an example to illustrate rather than prove a point, and he then moves on to connect this example of how a variation to the medium on which materials are produced or fabricated changes the resulting product. He next considers how nature can in the ‘bowels of the Earth make Decompounded Bodies’ (400.26-27), that is bodies that are further compounded or made up of compound constituents, and quotes as examples ‘Vitriol [iron sulphate], Cinnaber [mercuric sulphide]’ (400.28) and ‘Sulphur’ (400.29), the first two of which can be produced both naturally and in the laboratory. Interestingly, Carneades includes sulphur as a compound body, which, of course, has been recognised as an element by Lavoisier in 1789, and was also one of the *tria prima* of Paracelsus.

He then speaks of the separation of milk into its component parts not by fire, but by 'Runnet [rennet] and Acid Liquors' (401.2-3), which divides the milk into a solid and a liquid fraction, or, milk can be converted into 'Butter and Butter-Milk' (401.5-6), which in turn can be converted into other products. He goes on to counter the objection that dairy products may be reduced by fire into 'Hypostatical Principles' (401.14) that is, elemental bodies, by giving some examples of how some substances are dissolved. Firstly, he quotes the case of 'spirit of Wine [alcohol]' (401.17) and 'make them one Liquor with it self' (400.17-18) that is, dissolve it. This Carneades contrasts with '*Aqua Fortis* [nitric acid]' which will 'also disjoyn' (401.19) the parts of camphor, but instead of simply dissolving it, the nitric acid reacts with it and converts it into an 'Oyle' (401.22).

What Carneades seems to be doing here is simply contrasting the behaviour of camphor in alcohol (dissolution) with that in nitric acid (chemical reaction).[49] Carneades then goes on to speak of 'an uncompounded Liquor' (401.23-24) which an 'Extraordinary Chymist' (401.23-24) would not accept as being in any way 'saline' (401.25) and which can be made to obtain from 'Coral itself' (401.26) a 'noble Tincture' (401.28). This tincture carries over 'in Distillation' (402.2), and has

[49] Camphor is a terpenoid ketone, found in various plants including the camphor laurel (*Cinnamomum camphora*). Camphor dissolves in alcohol to give 'spirits of camphor'. It can also be oxidised by hot nitric acid to give 'camphoric acid', which forms colourless, prismatic crystals, and which would separate out of the 'oily' solution.

been prepared 'without the Intervention of Nitre or other Salts' (401.29-402.1) ['Nitre' here probably means nitric acid, which would dissolve coral].

What Carneades seems to be referring to here is a non-inorganic, simple substance which when distilled with coral gives a reaction product, and which, in turn, carries over in distillation as a coloured liquid. Coral consists mainly of calcium carbonate (that is, a chalk-like mineral), which dissolves in acids. So, what Carneades seems to have in mind is a process whereby the colourant of red coral (then, as now, prized as a precious or semi-precious mineral) was dissolved out of the coral substrate using a suitable organic solvent,[50] in a still. The red colourant would have been entrained in the solvent vapour and would have carried over with it into the receiver, to collect as a red solution. The coral substrate itself being unaffected by the organic solvent, would have been left behind in the retort.

Carneades then goes on to speak of a '*Menstruum*' (402.4) or solvent, of his own preparing, which can 'more odly dissociate the parts of Minerals very fixt in the fire' (402.5-6), and goes on to say that it seems 'not incredible' (402.7) that 'some Agent or way of Operation Found' (402.8) by which a 'concrete' (402.9) and perhaps all 'Firme Bodies' (402.10) may be separated into such miniscule parts so 'unapt' (402.11) or unlikely to adhere to one another as to be incapable of withstanding either a 'strong fire' (402.13-14) or 'Distillation' (402.14) and, as a consequence to be 'look'd upon as Earth' (402.15-16). In other words he believes that some

[50] What this solvent was is not clear, though it could have been acetone, which was probably the 'subtile spirit' (422.10) referred to by Carneades.

universal solvent or *alkahest* may be discovered, or some chemical reaction or process found, which is capable of reducing most, if not all, materials to volatile liquid products, which would boil away in a hot fire, or could distil over in a suitable still.

Carneades goes on to give another argument put forward by van Helmont: that earth is not an element. He makes the familiar statement of van Helmont's claim that he can 'reduce all the Terrestrial parts of mixt bodies into insipid water' (402.21-22), which probably refers to the latter's claim that he has produced an *alkahest* or universal solvent capable of reducing all bodies to a common aqueous state. This, Carneades states, presents another argument against the elemental status of earth, as Aristotle had believed and as argued for by Philoponus earlier in this dialogue. (See, for example, pp. 21-22 of *The Sceptical Chymist*).

He then goes on to say that for a material to be considered as earth more is required of it than simply for it to be an incombustible residue left over from which 'the fire hath driven away its looser parts' (403.2-3). It must also possess the qualities of 'Tastlessnesse and Fixtnesse' (403.6). He gives the example of 'Salt of Tartar [potassium carbonate]' (403.6-7) which is not considered by the 'Chymists' (403.8) as earth because of its strong taste. Carneades makes a further argument in relation to how the chemists actually decide on why an inert, solid body may be considered as earth. He says that even if a '*Capuut Mortuum* [inert residue]' (403.10) or some other material were to be rendered tasteless and unreactive through the use of

'Natural Agency' (403.9-10) the chemists will not readily state which part of a 'resolv'd concrete is earth' (403.14-15). Instead of indicating which part of the separated portions of a solid body is actually earth, they will simply state their definition of earth as 'a primary, simple, and indestructible Body' (407.16-17).

Carneades gives a further example of how the 'Vulgar Chymists' (403.20) claim to be able by adept chemical manipulation to be capable of causing the *Caput Mortuum* or inert residue of a chemical compound to distil over as a volatile liquid and not easily 'be taken for Earth' (403.26-27). He does allow that such an outcome may be possible by means of 'skilful' (403.27) treatment of the chemical compounds being manipulated. Tantalisingly Carneades quotes van Helmont as saying that it is possible for bodies to be converted either into earth or earth-like substances. Van Helmont achieves this objective by 'Art' (404.8) and has written of it 'in several places' (404.9-10). He gives two examples to illustrate his claim: the first is that of sulphur which 'once dissolv'd' (404.13-14) is completely converted into a 'Terrestrial Powder' (404.14-15).

What is now understood is that sulphur can exist in more allotropes or physical forms than any other element, depending on how it is manipulated. Van Helmont's dissolved sulphur may have been a hot, concentrated solution in alcohol, which when cooled gave 'nacreous' or 'mother-of-pearl' sulphur.[51]

[51]N.N Greenwood and A. Earnshaw, *Chemistry of the Elements* (New York: Pergamon Press,1984), 273.

In his second example Carneades says that van Helmont claims that 'the whole Bodie of Salt-Petre may be turn'd into Earth' (404.15-16), which transformation is somehow effected through the agency of the 'Odour only of a certain Sulphureous Fire' (400.18-19).

What exactly this account means is unclear. Perhaps he means that the saltpetre is burned in the presence of sulphur.[52] However, Partington gives the amount of the only solid product here generated as 15%, whereas van Helmont's claim was for the entire body of saltpetre to be converted into earth. However, he may not have weighed his materials, so when he said 'solid product' took it that all of the reactions had been converted into a solid product – earth, when in fact the only solid produced was potassium sulphide.

Carneades then returns to a favourite point of discussion – that of the production of plants from water. He recalls the account he gave earlier in this dialogue, of growing some mint in water only, which he describes in detail, starting on p. 110. Next, he describes Rondeletius's[53] account of the growth of a fish in 'a Glass of water without any other Food for three years' (405.8-9), but which kept on growing. Carneades argues that if this fish had been taken and distilled it would have 'yielded the like differing substances with other Animals' (408.17-18), and because the mint which he himself had grown in plain water had 'afforded me upon Distillation a

[52] Partington gives this reaction (in fact, the combustion of gunpowder) as: $2KNO_3 + 3C + S = K_2S + N_2 + 3CO_2$. In Partington, *General and Inorganic Chemistry*, 311.
[53] Guillaume Rondelet (1507-66), Professor of Medicine at Montpellier, and author of a book on the natural history of marine fish called *Libri de Piscibus Marinis*.

good quantity of Charcoal' (405.20-21) he feels confident in inferring 'that Earth itself may be produced out of water' (405.22-23). Or, to put it another way, that water may be transmuted into earth.

Carneades goes on to argue that even if it could be proved that earth is present in plant and animal tissue, from which it may be separated by the fire, it would not necessarily follow that earth as a pre-existent elemental body does not actually combine with other elements to constitute those bodies from which it has been separated.

Eleutherius provides an explanation for his approach by arguing that there is a distinction between what it is possible for nature to do and what she actually does. He states that he wishes to demonstrate how nature may be 'Conceived to have made Elements' (406.28-29) and not 'to prove that she actually had made Any' (406.29-407.1). He justifies this line of reasoning by saying that '*a posse ad esse* [from the possible to the actual]' (407.2) 'the Inference will not hold' (407.2-3). Carneades seems here to be allowing for the *possibility* of gold's being an element, but not going on to accept its elemental status, as he describes how gold might actually be destroyed. Carneades says that 'our Friend [that is, Boyle]' (407.12) has produced a 'certain *Menstruum* [solvent]' (407.11-12) with which he confidently asserts that he has 'destroy'd even refin'd Gold' (407.18), although his next statement does clarify what he really means by stating that the gold in question was 'brought into a Metalline Body of another colour and Nature' (407.19-20). Warming to his topic, Carneades continues that he has found from his own experimental work that 'such *Mentruums* May be Made' (407.25-26), not to destroy or change other materials but which may be able 'to entice away and retain divers parts' (407.26-27) from materials which even the *Spagyrists* have 'pronounced irresoluble by the Fire' (407.29-408.1). He is quick to point out that in neither of the two examples given were either of the two materials analysed 'the Gold or Precious Stones' (408.3-4) resolved into 'any of the *Tria Prima*' (408.5) but rather converted into new chemical compounds.

Carneades then speaks of the 'Disparity' (408.7) between the means by which the various 'Agents' (4.8.8) can act upon the different compound bodies and cause them to be 'Dissipated [separated]' (408.9). He gives as an example the solution of the 'purer sort of Vitriol [iron sulphate]' (408.10-11) in water. Here, of course, the iron sulphate simply dissolves in the water. Cool the solution, or evaporate off the water, and the iron sulphate will recrystallise and can be retrieved intact. Carneades says as much when he states that the liquor will 'swallow up the Mineral' (408.12), 'dissociate its Corpuscles' (408.13), and produce a homogeneous solution, though remaining a 'Vitriolate and Compound Body' (408.17-18).

He then contrasts this state of affairs with that which results when the 'same Vitriol be exposed to a strong Fire' (408.19-20), instead of dissociation, decomposition now occurs, into 'Heterogeneous Substances' (408.21-22), with those portions of the ferrous sulphate which had dissociated in the water now 'dissipated or divided into new Particles of differing Qualities' (408.25-27). What Carneades is here referring to is the thermal decomposition of ferrous sulphate,[54] by which reaction new chemical compounds are produced quite different in character from the original ferrous sulphate, and into which they cannot readily be returned.

Carneades reverts to his discussion about the destruction of gold, which puts him in mind of the question of the decomposition of materials into their putative elements. He speaks of those materials consisting of 'either Saline, or Sulphureous, or Terrestrial Portions of Matter' (409.4-6) whose 'parts' (409.6) cannot be divided either by fire or the 'usual Agents' (409.11-12). Carneades likens this inability to break down bodies with the propensity of a quantity of mercury which easily separates into small droplets, but these are equally likely to coalesce into larger drops. What Carneades seems to have in mind in making this comparison is that just as with a ball of mercury when broken up into globules, these are inclined to amalgamate rather than to remain separate and individuated, so any tendency of either fire or chemical agents to cause the incipient decomposition of chemical entities through a breakdown of their constituent parts would be overcome or checked by an equal proclivity for these micro-entities to reunite.

Yet, Carneades argues, this provides no conclusive evidence that 'such Permanent Bodies were Elementary' (409.17-18), since there 'may be Agents found in Nature' (409.19) with the capacity to separate 'seemingly Elementary Corpuscles' (409.22-

[54] When dry ferrous sulphate is heated to redness it undergoes the following reaction, with some decomposition at high temperature:
$2FeSO_4 = Fe_2O_3 + SO_3 + SO_2$. In Partington, *General and Inorganic Chemistry*, 708.

23) into even smaller units. However, Carneades cautions against this being considered as a means of revealing the 'Elementary Ingredients of Things' (409.29-410.1) simply by identifying the products into which bodies are subdivided. He argues that there is no necessity that 'such a Discovery should be practicable' (410.4-5). His reasoning seems to be that whatever solvent is employed to dissolve the body under investigation will itself interact with that body. For solvent-units will combine with the micro-particles they have dissolved and now 'they must constitute together new Bodies as well as Destroy the Old' (410.7-9). What Carneades seems to have in mind here is that the dissolution products which result from this process are newly formed compound bodies resulting from the combination of the solvent with some of the entities released by dissolution, as well as fragmentary particles resulting from the same process.

Carneades then describes another possible outcome of the efforts at effecting change to materials at the corpuscular level. He goes on to state that a putative elementary corpuscle 'may have its Nature changed, without suffering a Divorce of its parts' (410.21-22). He suggests that instead of modification through chemical reaction, a corpuscle may somehow be modified to that of a 'new Texture' (410.23). What Carneades seems to be considering here is the kind of change which can be effected to the hardness and transparency of corpuscles 'by the Operation of the Fire' (410.26).

Carneades then identifies 'the bare Change of Texture' (411.2) made with or without human intervention as the means by which 'New Qualities' (411.5-6) can be produced in a given portion of matter, and that it is 'these Qualities' (411.12) rather than 'any Imaginary Substantial Form' (411.10-11) that account for the variety of 'inanimate Bodies' (411.7). He goes on to argue that as 'the Fabrick' (411.18) of a body may be altered by either the 'figure … Size … Motion … Situation or Connexion of the Corpuscles' (411.14-16). He offers one the possibility to 'suspect' (411.19) with him that there is no real need 'that Nature should always have Elements before hand, whereof to make such Bodies as we call mixts' (411.19-23).

Carneades makes a second argument, this time on the presence of elements as building-blocks in materials, based on the difficulty of *identifying* any such elements. He says that it is not 'so easie as Chymists and others have hitherto Imagin'd' (411.23-25) among the many and varied decomposition products obtained in any given portion of matter to tell which should be 'esteemed exclusively' (411.29) as 'its in-existent [inherent] Elementary Ingredients' (412.1), and there is the added difficulty, he argues, of determining what 'Primogeneal and Simple Bodies convened together to compose' (412.2-4) that portion of matter. Carneades goes on to give examples drawn from the growth of plants to illustrate the foregoing.

Apart from those plants which he himself has gown – 'Mint and Pompions [pumpkins]' (412.10) nourished only, in his opinion, by water – he describes the growing of 'a slender Vineslip' (412.14-15). Interestingly, Carneades attributes its

'Nutrient' (412.16-17) not only from water but also to the 'warm'th of the sun or pressure of the ambient air' (412.19-20) which well display at least a suspicion on Boyle's part that both sun and air played some part in plant growth, two centuries or so before photosynthesis came to be understood. He goes on to speak of the 'strange quantity of Water will Drop out of a wound given to the Vine' (412.22-24), of the blandness of this '*Aqua Vitis* [vine water]' (412.26-27), and how little it differs from 'common Water' (413.2), then goes on to describe at some length the production of several substances by growing vines through the transmutation of water. He lists how 'many various Substances' (413.5-6) may be produced through the absorption of water by vine-roots. First to be produced are 'Wood, Bark, Pith, Leaves &c. of the Vine' (413.12-13). Then come 'sour Grapes, which express'd yield Verjuice [the acid juice of unripe grapes] a Liquor very differing in several qualities both from Wine and other Liquors obtainable from the Vine' (413.16-19). The sour grapes 'being by the heat of the Sun concocted [matured by heat] and ripened, turne to well tasted Grapes' (413.20-21). These if dried in the sun and distilled 'afford a faetid Oyle and a piercing *Empyreumatical* [tasting or smelling of burnt organic matter] Spirit' (413.23-24), rather than a vinous one. The same 'dry'd Grapes or Raisins' (413.25-26) when boiled with water make a 'sweet Liquor' (413.28), which when distilled yields an oil and a spirit, much like those of the raisins themselves' (413.29-414.1). Fermented grape juice when distilled yields 'not an Oyle but a Spirit [probably alcohol]' (414.6-7) which is inflammable and miscible with water. Carneades then states that he has obtained from 'one of the nobles sorts of Wine, pretty store of pure and curiously figured Crystals of Salt [probably the crust or layer of acid potassium tartrate deposited by some wines, especially port]' (414.13-15). He says that along with this product he also obtained from 'True and sprightly Wine' (414.18-19) a 'great proportion of a Liquor as sweet almost as Hony [Carneades may have distilled the wine and obtained an alcohol-rich spirit (a precursor to spirits such as brandy) as well as a sugar-rich residue left behind in the retort]' (414.16-17). He then lists some other products which separate from the wine, namely 'liquid Dregs or Leeze' (414.21) and partly into 'that crust or dry feculancy that is commonly called Tartar [a brownish-red substance consisting mainly of potassium hydrogen tartrate, present in grape juice and deposited during the fermentation of wine – this is much the same as the 'crust' already referred to]' (414.22-23).

Carneades continues that the tartar may be thermally decomposed into 'five different substances; four of which are not Acid, and the other not so manifestly Acid as the Tartar it self' (414.25-28). From such broad hints it is not clear what these five products are. He probably obtained some sugar-rich substance and some colourant, though the principle ingredient of tartar is potassium hydrogen tartrate (*cream of tartar*). This can be broken down to give potassium carbonate, which in turn breaks down to give potassium hydroxide.[55] He goes on to say that the 'same Vinous Juice after some time' (414.28-29) is converted into vinegar [a dilute solution of acetic acid], from which one may obtain by 'the Fire a Spirit and a Crystalline Salt, differing enough from the Spirit and Lixiviate Salt or Tartar [impure pyrotartaric acid and potassium carbonate, respectively]' (415.3-5). Carneades then says that if

[55] See: Partington, *General and Inorganic Chemistry*, 310.

'the Dephlegm'd Spirit of the Vinegar [concentrated solution of acetic acid]' (415.6-7) is poured onto 'the Salt of Tartar [potassium carbonate]' (415.7) the result will be 'such a Conflict or Ebullition' (415.6-9). He is here referring to the effervescence caused by the evolution of carbon dioxide when a strong solution of acetic acid is poured over potassium carbonate. Carneades goes on to describe how 'swimming Animals [vinegar eels (*anguillula aceti*)]' (415.13-14) may be present in vinegar.

Carneades finishes his account by saying that all of the above changes, and others, 'may the Water that is imbib'd by the roots of the Vine be brought' (415.21-23). And although he seems content that water has been transmuted into various substances by the plant, he does so cautiously, and apart from the plant itself, he says that the changes come about partly by 'supervenient [occurring after, or as an extraneous addition] Agent or Causes' (415.24-25). Then he adds 'without the visible concurrence of any extraneous Ingredient' (415.25-27), meaning perhaps that something *invisible* could be a part of the process (and as we now know, this is indeed the case).

Carneades then speaks of increasing 'the Variety of such Bodies' (416.1), but seems to believe that when 'the 'Vinous parts' (416.3) are reacted with other substances they do not add very much of these materials but only change their physical attributes, and end up 'associated after a New manner' (416.10-11). He goes on to describe how he prepared from a '*Caput Mortuum* of Antimony [perhaps the antimony ore stimnite (antimony sulphide), antimony oxide, or antimony metal]'

(416.12-13), added to ‘some other Bodies’ (416.13-14) which he had obtained ‘from Crude Tartar’ (416.15) a very Volatile and Crystalline Salt, differing very much in smell and other Qualities from the usual Salts of Tartar’ (416.15-18).

Eleutherius interrupts him, asking ‘how you make this Volatile Salt’ (416.23-24), as ‘Multitudes of Chymists’ (416.25) have ‘attempted in Vain the Volatilization of the Salt of Tartar [potassium carbonate]’ (416.26-28). And of course Eleutherius is correct in saying this, for electrolysis is required to decompose potassium carbonate, which process was not available until the nineteenth century. Hence the inability of the chemists of Boyle’s time to produce any product of tartar which would be ‘Volatile in a Saline Forme’ (417.2) or simply a volatile solid product from it ‘*in forma sicca*’ (417.3-4) or dry form. Carneades does not believe, however, that the salt in question is ‘that which *Paracelsus and Helmont* mean when they speak of *Sal Tartari Volatile* [perhaps pyrotartaric acid]’[56] (417.6-8).

The salt Carneades is speaking of is not very different in ‘its Tast, Smell and other Obvious Qualities’ (417.11-12) from ‘Salt of Harts-Horn [ammonium carbonate]’ (417.14) ‘and other Volatile Salts drawn from the Distill’d Parts of Animals’ (417.14-16). What Carneades seems to be referring to here is also ammonium carbonate, only this time prepared from other ingredients of animal origin, *e.g*. urine. Neither has he yet established that it is ‘a pure Salt of Tartar’ (417.18), but rather seems likely to proceed from the tartar, *i.e*. the starting material from which potassium carbonate is produced. He continues that ‘the Experiment is in it self not

[56] Pyrotartaric acid is made by the dry distillation of tartar.

Ignoble, and Luciferous [light emitting] enough' (417.23-25) to show a new route to the production of a 'Volatile Salt' (417.26), and then goes on to describe in detail how he prepared this particular salt.

He begins with 'good Antimony [perhaps the antimony ore (antimony sulphide); antimony oxide; or antimony metal itself]' (418.5), which may be the same as the '*Caput Mortuum* of antimony' (416.12-13) referred to earlier, possibly the antimony metal produced as a result of reducing an antimony ore to the metal. He adds to this 'Salt-Petre [potassium nitrate] and Tartar [potassium hydrogen tartrate]' (418.5-6) and 'Quicklime [calcium oxide]' (418.7). These are added to a 'retort of earth' (418.11) preheated in a 'Furnace for a naked Fire' (418.12) which is connected to a 'Receiver' (418.24) and the 'Fumes' (418.23) condense there 'into a Liquor, that Being rectifi'd [distilled] will be of a pure golden Colour' (418.25-26). The salt in question is separated from the liquor which is put 'into a glass Egg, or bolthead with a long and narrow Neck' (419.2-4), and which if placed in hot sand 'there will sublime up a fine Salt' (419.5-6). This product is 'much of kin to the Volatile Salt of Animals [probably ammonium carbonate]' (419.7-8). Carneades says that 'it has a Saltish not an Acid Salt' (419.8-9) (perhaps he means an acid *taste*). It 'hisses [effervesces]' (419.9) when 'Spirit of Nitre [nitric acid], or Oyle of Vitriol [sulphuric acid]' (419.10-11) is added. It 'precipitates Corals Dissolv'd in Spirit of Vinagar [*i.e*. precipitates calcium carbonate dissolved in acetic acid]' (419.11-12), 'it turns the blew syrup of Violets immediately green [*i.e*. it is alkaline]' (419.12-14), and 'it presently turns the Solution of Sublimate into a Milkie whiteness' (419.14-15) [which seems to mean that it precipitates a white solid (probably mercurous chloride or *sublimatus dulcis*) from its own solution – mercurous chloride is a white crystalline solid]. Carneades calls it '[*Sal*][57] *Tartari Fugitivus*' (419.20) on account of its being 'so Volatile' (419.19). So what exactly is this salt of which Carneades seems to be so proud? Two possibilities present themselves:

The *panacea antimonialis* of the French chemist Nicolas Lémery (1645-1715), made by boiling the scoria [slag or dross] from the preparation of antimony from a mixture of stibnite [antimony sulphide], tartar [potassium hydrogen tartrate] and saltpetre [potassium nitrate] with water and precipitating with vinegar. This product was formerly much used in medicine. It is antimony tetrasulphide or pentasulphide'[58]

The Bavarian chemist J. R. Glauber (1604-70) also had his *panacea antimonialis*, which was apparently antimony pentasulphide. He prepared it by dissolving antimony oxide in the acid obtained by distilling tartar [this distillate would have been pyrotartaric acid] and Glauber obtained what he called a *panacea* or universal medicine, which he claimed would cure the most virulent diseases, including all kinds of cutaneous eruptions. It might, he says, be the *alkahest* [universal solvent] of Paracelsus and van Helmont.[59]

Clearly, Carneades bears in mind the potential medicinal applications of his new salt, and 'a very ingenious Friend of mine tells me that he hath done great matters

[57] Added in *Errata*.
[58] See: Partington, *A History of Chemistry*, 3: 17.
[59] See: Partington, *A History of Chemistry*, 2: 357.

against the stone' (419.24-26) with a product close to that prepared by Carneades.[60] The 'very Experienced Germane Chymist' (419.28-29) may have been Peter Stahl, who taught Boyle, and others, chemistry in Oxford from 1659-64(?) and who told Carneades of a 'noted Chymist' (420.3) who had 'procur'd a Priviledge from the Magistrates' (420.4-5),[61] and produced a 'spirit' (420.7) in almost the same way as Carneades, except that he 'leaves Out one of the Ingredients, namely the Quick-lime' (420.9-10). This obviously means that calcium was not present in Carneades' preparation either.

Carneades then goes on to speak of the practice in France of preparing from grape skins and copper plates 'that Blewish Green Substance we in English call Verdigrease [basic copper acetate]' (420.21-23), which when distilled from that reaction product 'by the Association of the Saline with the Metalline parts' (420.26-27) seemed to both smell and taste to be 'strong almost like *Aqua Fortis* [nitric acid]' (421.1-2). It 'very much surpassed the purest and most Rectifi'd Spirit of Vinager [acetic acid]' (491.2-3) that he ever made. This seems to mean that the acetic acid produced was quite concentrated.

Carneades believes that the 'Spirit' (421.4) or acetic acid produced in this way results from the reaction of the 'Husks' (421.5) with the 'copper' (421.6-7), then inserts the proviso that 'though the Fire afterwards Divorce and Transmute them'

[60] The 'stone' referred to here is probably a hard, morbid concretion, especially in the kidney, gallbladder or urinary bladder.
[61] This may have been J.R. Glauber (1604-70), although he spent much of his adult life in Amsterdam.

(421.7-8), meaning that it may be that the fire can decompose them and convert them into other reaction products. His evidence for this is his finding the copper at the bottom of the retort in 'the Forme of a *Crocus* or reddish power' (421.10-11). He notes that copper is 'of too sluggish a Nature' (421.12) to distil over by 'no stronger a heat' (421.13-14), which of course is perfectly true as copper metal has a melting point of 1084^{o}C and a boiling point of 2567^{o}C, temperatures much higher than those attainable in a still.

Carneades continues that 'the Distillation of good Verdigrease' (421.15-16) never produced any oil, the nearest thing to it he obtained being 'a little black slime' (421.19), even though he remarks that 'both Tartar and Vinager' (421.21) 'yield a Moderate proportion' (421.23) of this same product. This he contrasts with 'both Tartar and Vinager' (421.21), which when distilled yields a 'Moderate proportion' (421.23) of oil.

Of course we would now explain this finding by saying that, whereas verdigris is a chemical compound, a solid, which when distilled would yield no distillate, apart perhaps from whatever impurities distil over, as Carneades' 'black slime' testifies, unless it is heated above its decomposition temperature. On the other hand tartar, as a substance settling out during the fermentation of wine, is a cocktail of ingredients, some at least of which are easily distilled over as 'oily' residues. Likewise vinegar, as a liquid product consisting mainly of water and a little acetic acid, nevertheless as an organic product made by the natural oxidation of wine, contains many other substances as well, some of which distil over as liquid residues.

Carneades goes on to describe the preparation of lead acetate by pouring ‘Spirit of Vinager [acetic acid]’ (421.24-25) onto ‘Calcin’d Lead’ (421.25) – by which he probably means lead oxide. He continues that the ‘Acid Salt of the Liquor’ (421.25-26) will react with the ‘Metalline parts’ (421.27) and although ‘Insipid’ (421.27-28) takes on after some time ‘a more than Saccharine sweetness’ (421.28-29). This illustrates his ongoing fascination with the transformation occurring in the conversion of sharp tasting vinegar [acetic acid solution] with lead to give the extremely sweet, though highly toxic, reaction product lead acetate.

Carneades then describes the distillation of lead acetate, and he says that the ‘Saline parts being by a strong Fire Destill’d from the Lead’ (421.29-422.1-2). In fact he seems to be describing the high temperature dry distillation of lead acetate which will decompose to give, first of all water, ‘phlegme’ (422.9), followed by acetone, ‘a subtile Spirit’ (422.10) and ‘with a strong smell very much other than that of Vinager’ (422.13-14), and ‘an unctious Body or Oyle’ (422.8), which is probably the red liquor called ‘fixed oil of lead’.[62] The residue left behind in the still consists of a metallic residue, ‘alter’d in some qualities from what it was’ (422.5-6).

Carneades employs the above description to illustrate how two materials can combine and subsequently decompose to form a set of products. He then says that

[62] See: Partington, *A History of Chemistry*, 2: 266.

the difference between materials 'may depend merely upon that of the schemes where into their Common matter is put' (422.19-21). Fire and other agents, as well as 'the seeds of Things' (422.21), are able to bring about changes in bodies by acting upon their 'minute parts' (422.23) in three possible ways: breaking them down into smaller bodies 'of differing shapes' (422.25), by combining 'these Fragments' (422.26) with undecomposed 'corpuscles' (422.27) or, 'such Corpuscles among Themselves' (422.27-28). Carneades describes how changes in the micro-constituents of materials may actually cause such changes and result in the formation of new products. He states that the means or mechanisms by which such new products may be produced from pre-existing corpuscles are: 'altering the shape or bigness' (422.29-423.1), partly by 'Driving away some of them' (423.1-2), partly by 'blending others with them' (423.3-4) and partly by 'some new manner of connecting them' (423.4-5). By invoking the above-mentioned possible mechanisms a given material may be given 'a new Texture of its minute parts' (423.6-7).

The destruction or alteration of one body allows for the production of one new body or another, all of which results from the 'small parts of matter' (423.9) interacting with other such bodies as they 'recede from each other, or work upon each other' (423.10-11) or are 'connected together after this or that determinate manner' (423.11-12).

In presenting all of the above arguments based on experimental evidence, Carneades is really arguing towards a case in which he states that all ‘the matter cloath’d with so many differing forms was originally but water’ (424.3-5), and if water is indeed the element from which all material arises there is no need to believe in ‘any Primogeneal and simple Bodies, of which as of Pre-existent Elements Nature is obliged to compound all others’ (424.15-18).

Carneades began this part of the discussion with an account of the reaction of vinegar and lead (which had already been calcined, or heated in air and forming lead oxide) to give lead acetate, or *sugar of lead,* which in turn decomposes to give water, acetone, fixed oil of lead and a metallic residue. Given that the vinegar was the end result of a chain of processes going back as far as grapes, and Carneades always had a strong suspicion that all plants resulted from the transmutation of water, he clearly believed that he was fully justified in arriving at this conclusion. The argument upon which the production of lead (and other metals) out of water he could validate from his assertion that not only ‘Fire and other Agents’ (422.21) could account for the occurrence of metals. Carneades said as much somewhat earlier in this dialogue when he stated that the ‘Bodies of Plants and Animals (and perhaps also of some Metals and Minerals)’ (381.1-3) he understands to be ‘the Effects of seminal principles’ (381.4-5).

Carneades gives another reason against the necessity for the existence of the elements: compound bodies can be understood as being produced ‘out of one another by variously altering and contriving their minute parts' (424.21-22) without reducing them to any elements 'as are pretended' (424.24-25). He continues that 'to dispatch [to finish off his opponents' argument]' (424.25) that when a material is decomposed by fire 'into its suppos'd simple ingredients' (424.28-29), that these decomposition products are not 'proper Elements' (425.1) but instead resulted from the fire's reducing them 'into minute Parts' (425.3-4) which being enclosed within 'Close Vessels' (425.5) 'necessarily bring them to Associate Themselves after another manner than before' (425.6-8), as facilitated by the composition of the breakdown products and the conditions under which they are now maintained.

Carneades adduces experimental evidence in support of this statement by saying that some compounds which when decomposed by the fire are validly classified as 'Oyle, and Salt, and Spirit' (425.18-19). Other materials 'such as are especially the greatest part of Minerals' (425.19-20), whose micro-constituents differ in some way or other from those just mentioned, when subjected to thermal decomposition yield 'others of differing Textures' (425.24-25). Still other materials 'Gold and some other Bodies' (425.26-27) do not yield 'any Distinct Substances at all' (425.28) in the fire. Indeed, Carneades continues, the decomposition products obtained by the chemists and called elements by them but which are in fact 'Compound Bodies' (426.3) are considered as elements because of 'their resemblance to them in consistence, or some other obvious Quality' (426.4-6).

A Commentary on
The Sceptical Chymist
of Robert Boyle:
THE CONCLUSION

Introductory Remarks

Carneades expresses doubts about the remarkable powers attributed to van Helmont's *alkahest*, arguing that direct visual evidence would be required before such claims could be accepted (427-428).

Eleutherius then attempts to bring the dialogue to an agreed conclusion by suggesting that if two sets of three propositions are accepted by Carneades, a list of three elements present in minerals and five present in plant and animal tissue may be proposed (431-433).

Carneades asserts that it is not the doctrines of the Paracelsians and Aristotelians he finds objectionable, but rather the quality of the experiments adduced by them in support of their claims (436).

THE CONCLUSION

The Sceptical Chymist begins as a dialogue of four participants, and ends with only two of them left – Carneades and Eleutherius. Now we are reminded of this fact when Carneades hears a noise 'which seem'd to come from the place where the rest of the Company was' (473 [427]. 3-4) and that it was time to finish the discussion. He hopes that Eleutherius will agree that if '*Helmonts* experiments be true' (473 [427].8-9) that is, those carried out by van Helmont with his *alkahest* or universal solvent, then he will consider it valid to question whether van Helmont's belief is one that it 'doth not assert Any Elements in the sence before explain'd' (473 [427].11-12). Which seems to refer to the implications of van Helmont's doctrine being that a universal solvent would actually reduce all matter to a common state – thereby discrediting the claims of the Aristotelians and the Paracelsians that a number of truly elemental substances exists.

Carneades then goes on to discuss van Helmont's claims for his *alkahest*, saying that 'the effects ascribed to that power are so unparallel'd and stupendous' (473 [427].16-17) that although Carneades admits that there '*may be* such an agent' (428.2) he is cautious in accepting its existence, saying that only αὐτοψία [autopsia, or seeing with one's own eyes]' (428.3) would confirm its reality to him. He continues with his doubts about the existence of a universal solvent by asking Eleutherius to consider that 'Arguments that are built upon *Alkahestical* Operations' (428.6-7), that is to say, a position put forward which holds that all materials can be reduced to a common state, a kind of unielemental sludge, are in fact 'weakened by that Liquors being Matchless' (428.8), possibly meaning that an argument predicated upon a highly improbably foundation is difficult to vindicate.

He goes on to state that it follows from the foregoing that the paradoxical opinion that 'rejects all Elements' (428.11) should be taken 'as an Opinion equally probable with the former part of my discourse' (428.11-13), in other words Carneades' earlier assertion that the probability of the existence of one element only – water – being based on good experimental results is a much more solid conclusion than an opinion which holds that there is a universal solvent capable of reducing all materials to a pre-elemental condition, but which assessment is based on the work of one man only, namely van Helmont, and upon whose testimony this doctrine is based without any independent verification having been carried out by Carneades. Keeping up this line of reasoning Carneades says that the arguments habitually advanced by the 'Chymists' (428.15) as proof of all materials being constituted 'of either Three Principles, or Five' (428.16-17) is not 'so strong' (428.18) as his own argument that there is not 'any certain and Determinate' (428.19-20) number of elements present in all compound materials.

Carneades then resiles somewhat from the opinions he has just presented and, adopting an uncharacteristically humble, hesitant tone, admits that he has not made the most of 'these *Anti-Chymical* Paradoxes' (428.23-24) in expressing his views on the number and nature of the elements, but offers the excuse that not having 'confin'd my Curiosity to Chymical Experiments' (428.26-27), but is still too young a man,[1] and a 'younger Chymist' (428.28),[2] and that he can only be as yet 'but

[1] Boyle was 34 years old when *The Sceptical Chymist* was published in 1661.

slenderly furnished' (428.29) with a knowledge of the aforementioned '*Anti-chymical* paradoxes' in the face of such a 'great and difficult a Task' (429.1-2) as Eleutherius has 'impos'd' (429.2) upon him.

Regaining his former authority, Carneades reverts to a more formal, scholarly tone by saying that he does not dare to 'employ some even of the best Experiments I am acquainted with' (429.4-5) as it is too early for him to 'disclose them' (429.6). He continues that the information on, or details of his experiments already disclosed, will suffice to convince Eleutherius that 'Chymists have been much more happy in finding Experiments than the Causes of them; or in assigning the Principles by which they may best be explain'd' (429.9-13).

Carneades' mood changes to a mixture of ridicule and admiration when he considers the writings of Paracelsus. On the one hand he says that he meets with 'such Phantastick and Un-intelligible Discourses' (429.15-16) which Paracelsus 'often puzzles and tyres his Reader with' (429.16-17), 'as though he seldom clearly teaches' (429.19). Yet, on the other hand he says that Paracelsus has had 'fathered upon [him] such excellent Experiments' (429.17-18) of which Carneades admits 'I often find he knew' (429.19-20).

Carneades now adopts a mocking yet curiously admiring tone as he likens the 'Chymists, in their searches after Truth' (429.21) to the 'Navigators of *Solomons Tarshish* Fleet' (429.22-23).[3] Just as those Biblical sailors returned home with 'not

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[2] Boyle began the academic study of chemistry, privately, in Oxford under the German chemist Peter Stahl in 1659.

[3] A reference to the Old Testament of the Bible, Tarshish – Old Testament and ancient port, mentioned in 1 Kings 10:22, situated in Spain or one of the Phoenician colonies in Sardinia.

only Gold, and Silver, and Ivory, but Apes and Peacocks too' (429.25-26), for 'your Hermetick Philosophers' (429.28) in their writings give us along with 'divers Substantial and noble Experiments, Theories' (429.29-430.1) which either 'like Peacocks feathers make a great shew [show], but are neither solid nor useful' (430.2-4), 'or else like Apes' (430.8) which, despite giving some reason to be considered as rational, nevertheless 'are blemish'd with some absurdity or other' (430.5-6) which, when they are '*Attentively* consider'd makes them appear ridiculous' (430.7-9).

Eleutherius says to Carneades that he has said 'more in favour of [in defence or support of] your Paradoxes' (430.16-17) than he had expected. He continues that 'divers of the Experiments you have mentioned are no secrets' (430.17-19), which seems to be Boyle's way of admitting that many of the experiments referred to in the work were already known to other experimenters, and as such he had not been the first to carry them out. Boyle, through Eleutherius, informs the reader that Carneades has 'added many of your own unto them' (430.21) and that from these same experiments has 'made such Deductions' (430.24) as Eleutherius has not 'Hitherto met with' (430.25-26), which seems to mean that Boyle believes that his own experiments allow for clearer insights into the behaviour of matter, than hitherto, to be obtained.

Curiously then Eleutherius gives some credence to the beliefs of the chemists, for he says that had '*Philoponus*' (430.28), an earlier participant in the dialogue, been present he would 'scarce have been able' (430.29) to offer a complete defence of the 'Chymical *Hypothesis*' (431.1-2) against the arguments ranged against it by Carneades. However, many of Carneades' 'Objections seem to evince a great part of what they pretend to, yet they evince it not all' (431.4-6). Then Eleutherius explains why this is so: the 'numerous tryals' (431.6-7) of 'the Vulgar Chymists, may be allow'd to prove something too' (431.7-9), which shows that Boyle still accepts the primacy of evidence obtained from practical experimentation even over what he himself had determined rationally, and also grudgingly accepts that other, even inferior experimenters, may arrive at some modicum of the truth about the behaviour of matter.

Eleutherius, acting as a good moderator should, sets about bringing the dialogue to a conclusion by summing up the most important points of the discussion and seeking agreement on them. He suggests three conclusions which Carneades' reasoning has made 'probable' (431.11). The first of which is that the likely thermal decomposition products of compound materials are not 'of a pure and an Elementary nature' (431.14-15), and he gives two reasons why this is so: firstly, he says that materials are not completely broken down through the action of the fire, retaining much of the original material 'as to appear to be yet somewhat compounded' (431.18-19), and secondly Carneades believes that those same decomposition products differ from the nominally identical ones obtained from a different starting material, the decomposition products often 'differ in one Concrete from Principles of the same denomination in another' (431.20-22).

Carneades continues that the number of decomposition products is not 'precisely three' (431.24-25) simply because in most organic bodies 'Earth and Phlegme [an aqueous product]' (431.26) are also present. He gives a further argument as to the number of the elements: he says that there is not 'any one determinate number'

(431.28-29) of ingredients into which fire decomposes ‘all compound Bodies whatsoever’ (432.2-3), as well as minerals and other putative compound materials.

Carneades presents his final argument on this subject, and probably his most telling objection to the doctrines of the fixed number of elements. He divides his argument into two parts: he refers to ‘divers Qualities’ (432.6) which cannot be said to derive from ‘any of these Substances’ (432.7-8). What Carneades seems to have in mind here are some materials which cannot easily be traced back to any of the sets of elements by the adherents of these doctrines. He then makes a second objection: that of those materials which seem to derive from one or other of the elements but ‘are not yet so deducible from it’ (432.13-14), but which still require something more than a given element to explain their existence. In fact they need ‘some more general principles’ (432.14-15) to account for their existence.

Eleutherius suggests to Carneades that if the foregoing ‘three Concessions’ (432.19) could be allowed to Carneades by the ‘Chymists’ (432.17) he could in return grant them ‘three other propositions’ (432.21-22) and goes on to list these as: ‘divers Mineral Bodies’ (432.23) but ‘probably’ (432.24) all of them ‘may be resolv’d into a Saline, a Sulphureous, and a Mercurial part’ (432.24-26). These three suggested materials correspond to the *tria prima* of salt, sulphur and mercury, and although, strictly speaking, the Paracelsians would have believed these to be the principles underlying all material things, in practice most of their analytical work was carried out on mineral bodies.

Eleutherius goes on to say that 'almost all Vegetable and Animal Concretes' (432.26-27) may by employing (mainly) fire be 'divided into five differing Substances, Salt, Spirit, Oyle, Phlegme and Earth' (433.1-3). Interestingly, Eleutherius subdivides these five principles into two sub-groups: 'the Three active Principles' (433.6-7) – the first three named – these 'being so much more Operative' (433.4-5) 'Deserve' (433.6) to be considered as the 'Three Active Principles' (433.6-7). What Eleutherius seems to mean is that salt, spirit and oil are, of the five principles, the ones that most determine the nature, appearance and behaviour of compound materials, whereas water and earth are not so obvious in deciding a body's characteristics: they play a more foundational role in the formation of materials. He continues that the first three elements named deserve 'by way of Eminence to be call'd the three principles of mixt bodies' (433.7-9).

Eleutherius then moves on to his next preposition in which he actually names the above-mentioned principles as 'the Elements of Compound bodies' (433.13-14), even though he admits that they may not be 'perfectly Devoid of all Mixture' (433.11-12). He gives three criteria by which materials might be considered as elements: 'they bear the Names of those Substances which they most resemble' (433.14-16); these substances 'are manifestly predominant in them' (433.16-17); and 'that none of these elements is Divisible by the Fire into Four or Five differing substances' (433.18-20). Eleutherius' third proposition is concerned not with matter itself but with its qualities, and in particular its 'Medical Virtues' (433.23-24), and he is at pains to point out that such properties are to be found in *one* of the principles of a compound material, which means that they can be analysed for in 'That Principle sever'd from the others' (433.27-28).

Eleutherius then attempts a form of reconciliation between Carneades and the chemists, or perhaps more precisely wishes to acknowledge the common ground between the two, by reminding Carneades that both he and his opponents the 'Chymists, may easily agree, that the surest way is to learn by particular Experiments' (434.1-3). Not only do they share an acceptance of a common experimental method, they may also share a common belief in avoiding an over-reliance on fire as a means by which compound materials 'may best and most Conveniently be Separated' (434.6-8). Curiously, Eleutherius employs the term 'either Actual or potential fire' (434.5-6) as representing two ways by which bodies may be separated, and it is not obvious what he means. By actual fire he may mean the fire as it would be produced in the chemist's furnace, that is, the heat and flames generated by burning a fuel such as charcoal or coal. And potential fire may refer to the power of heat produced by some means other than by fire to act on bodies, for example, the heat given off in an exothermic chemical reaction, when heat is produced during the reaction of two or more chemicals.

Eleutherius is anxious that Carneades and the chemists should come to the common agreement that compound bodies should be separated 'without relying too much upon the Fire alone' (434.8-9) in decomposing bodies into their primary constituents. Eleutherius has another reason in eschewing the excessive use of fire in chemical analysis, for he argues that fire can be an excessively aggressive agent of decomposition, and result in either of two possible outcomes: it can force compound bodies 'into more Elements than Nature made Them up of' (434.11-12). What he seems to have in mind here is that a very hot furnace could attack a compound so vigorously as to reduce it to a stage beyond the elemental – or the elements of the body themselves might be reduced to the condition of single corpuscles – to the stage of decomposition of which they themselves consist. The other difficulty inherent in the use of fire to decompose bodies is that materials could be broken down to the point at which the elements are themselves left behind after other extraneous matter has been resolved or reduced as to leave 'the sever'd Principles so naked' (434.12-13) that they have now been reduced to such a state of decomposition that being 'Exquisitely Elementary' (434.14) they are no longer capable of participating in chemical reactions and are 'almost useless' (434.15).

In coming to the end of the dialogue Eleutherius wishes to distance himself from Carneades' opinions, when he says that 'it will be no disparagement to you to recede from some of your Paradoxes' (434.24-26), and the reason why he should wish to do this is because these are no more than an expression of his opinions on the hypotheses of his adversaries, rather than those of Carneades himself. Eleutherius says that Carneades had expressed 'your own opinions, but only to personate an Antagonist of the Chymists' (434.28-29 - 435.1).

Carneades hints that he is willing to express his own opinions on the subject of the elements, but will do so at some future time. He says that he awaits the opportunity to 'Acquaint you with my own Opinions about the controversies' (435.8-10) which they had discussed and would withstand 'my own sence of the Arguments I have employ'd' (435.12-13).

Carneades then refrains from speaking of his own opinions on the elements and reverts to occupying himself with those of his adversaries. He offers an insight into how he regards himself by saying that ‘not only an acute Naturalist, but even I my self could take plausible Exceptions at some of them’ (435.15-17). However, he does believe that his negative comments on their doctrines have struck home as several of them ‘will not perhaps be readily answer’d’ (435.18-19). Not only this, Carneades believes in the forcefulness of the arguments he ranges against them and that they will ‘Reduce my Adversaries at least, to alter and Reform their *Hypothesis*’ (435.20-21). He then makes an admission, which he acknowledges Eleutherius already realises: it is that his ‘objections’ (435.23) against the ‘Quaternary of Elements’ (435.24-25) are not aimed so much ‘against the Doctrines Themselves’ (435.26) which he says ‘may be much more probably maintain’d’ (435.28-29) by their proponents, but ‘against the unaccurateness and unconcludingness’ (436.2-3) of the experiments purported to demonstrate them.

Carneades expresses his willingness to accept any given set of elements presented to him ‘upon rational and Experimental grounds’ (436.9-10). He avers that he does not adhere to his ‘Disquieting Doubts’ (436.14) so tenaciously as not being willing ‘to change them for undoubted truths’ (436.15-16).

In his concluding statement Carneades demonstrates his absolute scepticism on the question of the elements by admitting that the doctrines of the ‘Peripateticks, and the Chymists’ (436.21) are perhaps no ‘more unsatisfactory to me, than my own have been to my self’ (436.25-26).

DISCUSSION and CONCLUSION

DISCUSSION and CONCLUSION

Discussion

Authority and Autopsia

Boyle's seeking after secure knowledge is guided throughout *The Sceptical Chymist* by two principles: authority and autopsia. The first of these is taken here to mean the various kinds of authority which are invoked in the unfolding text. The highest of these is Biblical authority: Boyle as a devout Christian believed implicitly in the Genesis version of creation, and makes effective use of it in formulating his own understanding of the details of how corpuscularised matter in motion came to be.

Accounts of things less fundamental than creation Boyle also takes seriously, although he cannot accord these the absolute authority of the Bible. There exists an ongoing tension in Boyle, as expressed through Carneades, whereby he calibrates the claims of the various writers whose opinions and doctrines he considers against his own sense of the plausibility of the account in question. The criterion against which he measures it is autopsia, seeing for oneself, which to Boyle is of near paramount importance, second only in credibility to his acceptance of the word of the Creator, as expressed in the Bible.

The Oxford English Dictionary defines autopsia as:

> The action or process of seeing with one's own eyes; personal observation, inspection, or experience. Now *rare*.[1]

[1] O.E.D. – online, consulted 30-05-2014.

Probably the clearest expression of autopsia is given by Carneades, when speaking of a favoured topic – the *alkahest* or universal solvent of van Helmont – when he declares 'I am not sure but that there *may be* such an Agent, yet little less than αὐτοψία seems requisite to make a man sure there *is* (428.1-4). He provides ample evidence throughout the text of his admiration for the work and achievements of a man whose experiments he himself has, in part, replicated (as in his plant growing experiments) yet he withholds assent to the Helmontian belief of water as the sole element, but most especially to his belief in the *alkahest*: he lacks autopsia on the matter.

Another striking example is when Carneades (usually acting as Boyle's own spokesman, or even *alter ego*) asserts that 'our Friend Mr. *Boyle* is wont to say, when he is askt his Opinion of any strange Experiment; *That He that hath seen it hath more Reason to beleeve it, than He that hath not*' (78.12-16). This is probably as close as Boyle is going to get in *The Sceptical Chymist* to saying that something is very important indeed, as much as to say 'let there be no doubt about it, this is what I, Robert Boyle, believe to be of special significance', and this statement deals with the importance of autopsia. Seeing for oneself can never be improved upon in matters relating to knowledge of the physical world.

Sometimes Boyle can test things for himself, as with the plant-growing experiments just cited, other times he cannot, as for example, when speaking of the growth of metals and minerals, or when the English winter did not turn sufficiently cold to allow the freezing of alcoholic beverages, and he had to look to reports from colder regions. In these, and other, cases, when the subject of autopsia, Boyle himself, cannot personally investigate a particular matter, he must cede authority to another subject of autopsia – a traveller or other investigator – and only when he is satisfied with the authority of this other reporter is he content to credit another's autopsia.

Boyle is presented with the obvious difficulty of determining exactly whom to believe. He behaves in a typically cautious manner, and is fully accepting only of the account of creation as related in the Old Testament of the Bible. This is evident from the four propositions proposed by Carneades on the first production of subdivided matter, and the motion which was superadded to it.

In his first proposition on the subject, Carneades posits that:

> *It seems not absurd to conceive that at the first Production of mixt Bodies, the Universal Matter whereof they among other Parts of the Universe consisted, was actually divided into little Particles of several sizes and shapes variously mov'd* (37.1-7).

What he is postulating is that the universal matter was subdivided into minute particles, and that these particles, once subdivided, had motion added to them by their creator. In other words, what Carneades takes as reasonable assumptions in relation to the production of atomised matter in motion is that the process of subdivision of matter, and the addition of motion to it, occurred through divine agency.

What he makes no assumptions about, is in relation to the production of matter itself. The 'mixt Bodies' and other parts of the universe were composed of 'the Universal Matter' the origin of which is unstated. Boyle takes it for granted that the prime matter was produced through divine agency, at the time of creation, as narrated in the Book of Genesis. Carneades may postulate a scheme by which matter was subdivided, and had motion superadded to it, as strictly speaking, this is not stated explicitly in the Bible as having occurred. He makes no suppositions about the origin of the matter itself. He has it on the authority of 'the inspir'd Historian' (38.6) 'informing us' (38.7) of how 'the great and Wise Author of Things' (38.7-8) produced animals and plants 'out of those portions of the pre-existent, though created, Matter, that he calls Water and Earth' (38.10-12). Biblical authority informs us that matter was created by divine agency, and this is accepted unquestioningly and without any hesitation or qualification by Carneades.

At times authority and autopsia come into conflict, as when Carneades gives his response to the Aristotelian dictum on heat, which he explains is the true 'Definition of Heat given by *Aristotle*' (85.13). That this is a definition given by a figure of authority is reinforced by Carneades when he says that it is 'Generally Received' (85.14). He relates it as '*Congregare Homogenea, & Heterogenea Segregare*, to Assemble Things of a Resembling, and Disjoyn those of a Differing Nature' (85.14-17).

Carneades immediately indicates his opposition to this definition, however authoritative it may be, by posing objections to it based on his own autopsia. His first is that, in his opinion, the effect of heat is to set moving, and dissociate the component parts of bodies, 'and Subdivide them into Minute Particles, without regard to their being Homogeneous or Heterogeneous' (85.23-26). Carneades can only posit that this is how bodies behave when heated, as he cannot have direct knowledge of the behaviour of bodies at a truly microscopic level. Nevertheless his justification for postulating this hypothesis is based on direct observation of the behaviour of materials, in water boiling and in mercury being distilled, 'or the

Exposing of Bodies to the action of the Fire' (85.28-29), which are apparently homogeneous in composition. The fire does only what it is capable of doing, and that is to convert those materials into vapour which can be condensed to give the original liquid, and nothing more, or into ashes, the particles of which resemble each other, and constitute the only combustion products the material in question can yield when burned.

He elaborates that even if bodies seem to behave in accordance with Aristotle's dictum, this is purely accidental, for bodies invariably behave in accordance with the physical laws of nature. A given body when burned, he explains, undergoes dissociation of its physical structure, releasing the component parts of the body, and these behave strictly in accordance with those physical laws which apply to such bodies. It is properties such as density, inertness or volatility which determine their behaviour. Sometimes these properties favour the association of the decomposition products, as when light components congregate, but this is due to their possessing a common density and nothing more. Simple observation shows how decomposition products aggregate, lighter parts with lighter parts, heavier with heavier, and it is the degree of fire which determines the nature and physical form of the decomposition products.

Autopsia reveals how human blood distils: first it is dissociated by the heat, then the most volatile component – water – distils over and condenses. Only a hotter fire will decompose the other components of the blood, 'the Volatile Salt and the Spirit' (87.12), which although believed to be different components, are actually almost equal in volatility. Next to distil over is the oil, which Carneades explains, is less fugitive than the preceding fraction, the ‘Earth and the *Alcali*’ (87.18), which being solid and equally non-volatile, are not separated by the fire.

If instead of this careful distillation, the product to be distilled is thrown into a red-hot retort, ‘You may Observe, as I have often done’ (87.23-24) that the overwhelming fire causes all of the volatile components to be carried up all together in one undifferentiated body, but having distilled over, these will settle to their own levels in the receiver, according either to their density, or their state. The solid component will adhere to the sides and top of the flask, with the aqueous fraction present as large drops. Depending on the relative densities of the ‘Oyle and Spirit’ (88.5) one of the two will float on top of the other.

All of the details stated here by Carneades are informed by his meticulously conducted direct observations, and he is in no mood to countenance any doctrine which is not as equally grounded on autopsia as his own, hence his side-swipe at the ‘Schools’ (87.21) ‘for all the Definition’ (87.20) taught by them. Carneades’ own observations of the progress of a laboratory process always overrules the dictates of, for him, a suspect dogma. As further evidence in favour of his assertions on the distillation of blood he ‘can shew You in some Oyls of the same Deers Blood, which are yet by Me’ (88.18-20). In a final example he can show one two oils made from the same sample of human blood, which are not only extremely different in colour, but form two distinct layers, and even if these are agitated they will revert to their original separated condition. This account provides further evidence that even if a batch of product is separated and subjected to differing thermal histories, the decomposition products will behave in compliance with the physical laws governing the behaviour of natural bodies, and not in accordance with the dictates of a rationally-derived doctrine, irrespective of the standing of its author.

The foregoing examples demonstrate that in examining a traditional and widely accepted doctrine Boyle is prepared to approach it in an open-minded manner and without positing some counter-dicta of his own. He proceeds to enumerate several examples consisting of the observations of the enforced physical separation of compound materials, followed by their reagglomeration in accordance with natural physical processes. Carneades supplies as much detail of the operations undertaken as a means of assuring the reader of the justification for, and veracity of, the knowledge claims arising from his experiments. Boyle is aware that his readers may well accept the Aristotelian dictum on the effect of fire on materials, and probably believes that the best approach is not to contradict the proposition in question, or propose one of his own in its place. What he does instead is report his experimental findings dispassionately, piling observation upon observation and experiment upon experiment, all the while allowing this information to impress upon his readers a mass of detailed evidence arising from personal observation, and which may cause the readers to rethink their assessment of Aristotle’s dictum. Sufficient information is supplied to the readers to allow them to repeat Boyle’s experiments in their own laboratories, if they so wish, and bring their personal autopsia into play in informing their judgements on the matter.

Carneades gives further consideration to the question of the effect of cold on materials in relating Paracelsus’ doctrine on the freezing of wine. He states that Paracelsus ‘Teaches that the Essence of Wine may be Sever’d from the Phlegme and

Ignoble Part by the Assistance of Congelation' (95.7-10). He is neutral in relation to the veracity of Paracelsus' claim, as he explains that he has not been able to put it properly to the test, because the English winters were not sufficiently cold to freeze wine completely through its entire bulk. He realises that unless the temperature is low enough, liquors will not separate 'their Aqueous and Spirituous Parts' (97.2). He relates how he has a few times frozen 'Red-wine, Urine and Milk, but could not Observe the expected Separation' (97.4-6). Unable to cause the liquors in question to freeze, he resorts to relating two accounts of the freezing of beer or ale and wine in countries with winters colder than his personal experience afforded him.

The first of these is an account he read of some Dutchmen overwintering in Novaya Zembla, or Novaya Zemlya, off the northern coast of Russia. They give a detailed account of the freezing of beer, and carefully relate the stages by which it froze, and the condition of the freezing liquor at various times throughout the process. His second account is from 'a neere Friend of mine' (101.8), who froze some beer or ale whilst living in Holland, observing that it froze into ice and 'a very Strong and Spirituous Liquor' (101.14-15). Carneades obviously gives full credence to his friend's account and with it he 'might Confirm the Dutchmens Relation' (101.6-7). Autopsia enabled him to experience the partial freezing of some materials, but thwarted by insufficiently low temperatures, shifts to ersatz autopsia, by placing full reliance on his trusted friend in Holland. He is content to accept his friend's autopsia as the standard by which he judges the other accounts of the freezing of liquors. He does not reject the Paracesian account, but simply cannot 'lay much Weight upon this Process' (96.15-16), and as he is unable to put it to the test for himself, chooses to withhold judgement on it. He is unwilling to place the same level of trust in

Paracelsus as he does in his friend in Holland, and despite the widespread acceptance by others of Paracelsus as a figure of authority, Carneades refuses to accept him at his word.

The same Dutchmen relate how their Spanish white wine, or sack, froze solid in December, during their stay in Novaya Zembla [Zemlya], unlike their beer which froze into different fractions when it froze in October. Carneades understood from his own observations that liquors or plants did not freeze completely, yet he did not reveal whether he believed this account, and is probably neutral about it. Of course it is likely that it did freeze solid, due to the lower ambient temperatures in December than in October.

Boyle's Water Hypothesis

One of the most important themes running through *The Sceptical Chymist* is Boyle's hypothesis that water may be the primal element, a notion which he does not claim to have originated, for he says that 'the Opinion it self is very Antient' (118.28-29), and goes on to relate several instances in which doctrines were posited on water as the primal element by various authors of antiquity. He traces the opinion back through different sources to the Phoenicians, then asserts 'For 'tis known that the *Phoenicians* borrow'd most of their Learning from the *Hebrews*' (120.17-20).

It would seem that Carneades is willing to accept that much of the importance of water to the formation of the world derived ultimately from the Bible, for him the most secure authority. Yet when he narrates his account of the formation of the created universe, as related in the Book of Genesis, he recounts it in language which makes it appear as just another opinion on the matter, and not as the word of God.

For example, when he notes that among those who accept the Bible, 'many have been inclin'd to think Water to have been the Primitive and Universal Matter' (120.21-24). He goes on to quote 'the Beginning of *Genesis*, where the Waters seem to be mention'd as the Material Cause' (120.24-26) of all the bodies which constitute the universe.

Carneades does not seem to have found definitive support in the Biblical account of creation for the hypothesis on water, as his use of such phrases as 'inclin'd to think', and 'the Waters seem to be mention'd', indicate that he cannot invoke Biblical authority as indubitably in favour of the water hypothesis. His finding of a lack of a dogmatic assertion on the question in the Bible no doubt informed his own opinion on the matter, and contributed to his ambivalence on the subject.

Later in the text Carneades makes a clearer statement on how he interprets the Biblical account on the role played by water at the time of creation. He explains that 'I see no Necessity to conceive that the Water mention'd in the Beginning of *Genesis*, as the Universal Matter, was simple and Elementary Water' (128.16-20). Biblical authority cannot be invoked in favour of water as being present at the time of creation: all he can be sure of is that a liquid resembling water played a part in the unfolding process of creation. The inference from this is that one cannot find secure Biblical support for the doctrine that all created bodies ultimately derive from water. Without univocal Biblical support Carneades himself cannot enunciate a clear, unambiguous doctrine as to whether water is the sole element.

DISCUSSION & CONCLUSION

One of the central issues treated of in *The Sceptical Chymist* is the role of water in the growth of plants, with Carneades deliberating on whether he agrees with van Helmont that all plant tissue derives from the transmutation of water. He recounts a series of experiments carried out either by himself or under his close supervision on the growth of vegetables. He obviously accepts the reality of the transmutation of water into plant tissue, for he says of the growth of one of his cucumbers that 'it appears that' (109.19-20) 'the main body of the Plant consisted of Transmuted Water' (109.22-23). Likewise he relates his own experience of growing some plant slips in water which he made in his chamber.

Carneades goes on to discuss the tree-growing experiment of van Helmont, whom he holds in high regard, and introduces him as 'an Author more considerable for his Experiments than many Learned men are pleas'd to think him' (112.21-23). He admits 'But perhaps I might have sav'd a great part of my Labour' (112.19-20), by which he seems to mean that he regarded van Helmont as having such great authority that he might simply have accepted his account and not put himself and his gardener to the trouble of carrying out some unnecessary plant-growing experiments. Having mentioned van Helmont's tree-growing experiment of five years' duration, he apologetically says that 'I should scarce Think it fit to have his Experiment, and Mine Mention'd together' (113.1-3).

However great his faith in van Helmont as a figure of authority, Carneades is not without his reservations, as, when speaking of van Helmont's assertion that the tree consisted solely of transmuted water, he cautions that 'so Paradoxical a Truth as that which these Experiments seem to hold forth, needs to be Confirm'd by more

Witnesses then one' (113.6-9). In fairness, this may represent a move by Carneades to promote an inductive methodology for arriving at more secure knowledge on the working of nature, an opinion which van Helmont did not seem to share. Then follows a truly negative assessment of van Helmont's authority as an experimenter when he adds to the foregoing quotation 'especially since the Extravagancies and Untruths to be met with in *Helmonts* Treatise of the Magnetick Cure of Wounds, have made his Testimonies suspected in his other Writings' (113.10-14). However, Carneades restores van Helmont's reputation somewhat by continuing that 'though as to some of the Unlikely matters of Fact he delivers in them, I might safely undertake to be his Compurgator' (113.14-17). He is willing to vouch for at least some of van Helmont's implausible claims.

In examining the claims made regarding the water hypothesis, Carneades drew upon two distinct sources: his own autopsia and the ersatz autopsia of his conscientious gardener, in addition to the account written by van Helmont. Although he greatly admired van Helmont, he is fundamentally ambivalent about his knowledge claims, but his uncertainty stems not so much from van Helmont's persistence and meticulousness as an experimenter, which qualities he admires, nor about the importance of water to plant growth, but rather to the inferences or conclusions van Helmont draws from his tree-growing experiment.

Carneades never was convinced that plant tissue was composed of water, and water only. He always suspected that the air itself or some bodies present in the water, played a role as well. Of course, this suspicion came to be vindicated, but only about two-hundred years after Boyle's time. He thought that rainwater, as opposed to spring-water, 'is more discernably a kinde of πανσπερμια' (112.6-7) which even if free of obvious impurities, seems to contain 'the Streams of several Bodies wandering in the Air, which may be suppos'd to impregnate it' (112.9-12). This may be a reference to the presence of pollen grains and dust in the atmosphere, and in addition 'a certain Spirituous Substance, which may be Extracted out of it' (112.12-14), a prescient notion of the presence of a constituent of the air, now identified as carbon dioxide, which is removed from the air during photosynthesis, and which plays a crucial role in plant growth.

Growth of Minerals and Metals

Carneades considers the formation of minerals, and demonstrates that he has some understanding of the lengthy time-scale involved in their formation, although he may mean long with respect to the Biblical age of the earth rather than to our present-day understanding of geological time. He acknowledges that for this he will have to set aside his investigation of nature by direct experiment, and resort instead to examining the finished minerals in order to determine the manner of their formation. He notes that the growth or increase of minerals, apart from being an extremely slow process 'and for the most part perform'd in the bowels of the Earth, where we cannot see it, I must instead of Experiments make use, on this occasion, of Observations' (356.9-13).

He posits that mineral formation is a process which continues to the present day, although acknowledging that what he believes is not accepted by all, nevertheless he asserts that his model for the mechanism of mineral growth may 'be fully prov'd by several examples' (356.17-18), of which he needs to do no more than quote one.

This is of a French limestone cave called *Les Caves Goutieres*. He relates a succinct account of calcite formation, ‘where the Water falling from the upper Parts of the cave to the ground does presently there condense into little stones, of such figures as the drops, falling either severally or upon one another, and coagulating presently into stone’ (356.21-26).

This account seems to have been influenced by Aristotle’s *Meteorology*, in particular by his account of the formation of hailstones, amber and calcite. Speaking of hail formation, Aristotle says that it results when the ‘cloud is thrust up into the upper region, which is colder’ (*Mete*. I.348^{a} 15-16).[2] He goes on to say that upon arrival there, the water freezes. The hailstones thus formed, differ in size and shape, some being large and angular, others ‘round and smaller in size’ (*Mete*.I.348^{a} 36). Carneades makes a similar distinction between the drops that fall ‘severally’ and form small calcite stones, and those that fall ‘upon one another’ as they fall through the cave, and then ‘coagulating presently into stone’.

Aristotle says that there are different processes involved in the formation of solid bodies; some being formed by cold only, such as hail, others by heat only, or by both heat and cold. Interestingly amber and other bodies ‘called “tears” are formed by refrigeration, like myrrh, frankincense, gum’ (*Mete*. IV.388^{b} 19-20). And some of Boyle’s calcite stones are ‘of such figures as the drops’. For Aristotle, stalactites ‘cannot be melted or softened’ (*Mete*. IV.388^{b} 25), and are formed not through the agency of fire but rather cold which ‘draws out the moisture with it’ (*Mete*. IV.388^{b} 29) and causes it to solidify. For Boyle, by contrast, no heat is involved in the

[2] J. Barnes, ed., *The Complete Works of Aristotle*, vol. 1 (Princeton: Princeton University Press, 1984).

formation of calcite in caves. The drops of calcium carbonate solution falling through the air undergo a process involving ‘coagulating’ into stone, with no mention of the water from which they are largely constituted. Presumably, the solution in its entirety becomes transmuted into calcite through a mechanism of coagulation, although Boyle does not state this explicitly.

Carneades’ account is obviously very close to that of Aristotle, although he makes no mention of the Stagyrite in his text. What he does disclose is that ‘Of these stones some Ingenuous Friends of ours, that went a while since to visit that place, did me the favour to present me with some that they brought thence’ (356.27-29 – 357.1-2). He has it on the authority of ‘Ingenuous [noble in nature] friends’ that the calcite samples they gave him did come from the cave in question, and having possession of these rock fragments can observe their morphology and composition for himself. It is probable that he concluded from his examination of these pieces of calcite that Aristotle’s explanation of liquids condensing to form solid materials was valid, though he makes no effort to acknowledge it. He may be reluctant to admit his indebtedness to the Stagyrite, although in adopting the Aristotelian mechanism on mineral formation he is clearly accepting him as an authority figure.

Carneades has no first-hand informants on the production of diamonds, though seems to accept the notion of diamonds as regrowing in the ground from which they have been depleted. His evidence for this comes from two sources: ‘that sober Relator of his Voyages, *Van Linschoten*, and another good Author’ (357.3-5). These two accounts obviously provide sufficient authority for Carneades to credit them, even prompting him to supply a possible mechanism by which the regeneration may take place, surmising that 'From both which Relations, especially the first, it seems probable that Nature does not alwayes stay for divers Elementary Bodies, when she is to produce stones' (357.12-16), by which he may mean that both the matter and organising principle responsible for producing diamonds are always present in the diamond beds, and can immediately set about generating new gems, once the existing diamonds have been removed.

Turning to the production of metals, Carneades states that 'Authors of good note assure us' (357.17-18) that metals did not all originate at the same time 'but have been observ'd to grow' (357.20). Many 'professed Chymists' (357.23-24) may be quoted on this. He continues: 'But that they may have the greater authority, I shall rather present you with a few borrowed from more unsuspected writers' (357.24-27), by which he seems to mean writers who are not considered to be suspicious or doubtful. The writers he quotes from are 'the inquisitive *P. Fallopius*' (357.28), Pliny the Elder, whose account of the growth of iron in Elba, not only is 'countenanced [supported] by *Fallopius*' (158 [358].14-15), but is mentioned 'by the Learned *Cesalpinus*' (158 [358].18-19). This latter author's account of the growth of iron on Elba so convinces Carneades that he asserts 'Which last clause is therefore very notable, because from thence we may deduce, that earth, by a Metalline plastick principle latent in it, may be in processe of time chang'd into a metal' (158 [358].25-29). He cites further accounts from Georgius Agricola, Galen, Boccacio, Gerhardus the Physick Professor, Johannes Valehius and Johannes Agricola. He concludes from the differing, though reliable accounts of the growth of metals, that they allow: 'this I may at present deduce from these Observations' (363.20-21) that when nature is to produce a metal or mineral deep inside the earth she does not require 'both Salt, and Sulphur, and Mercury to Compound it of' (363.26-27), even though some of the accounts related are more favourable to the Aristotelian doctrine which 'would have Metals Generated of certain *Halitus* or steams' (364.1-2). Carneades seems to agree in part with Aristotle when he concludes that 'the forementio'd Observations together, make it seem more Likely' (364.2-4) that 'the mineral Earths or those Metalline steams' (364.4-5) contain 'some seminal Rudiment' (364.7-8) or its equivalent, which over the course of time is converted 'into this or That metalline Ore' (364.12-13). He reinforces his organic growth analogy by likening it to the growth of plants (treated of earlier) when plain water by 'seminal Principles' (364.14-15) is fashioned into specific vegetables.

Carneades clearly believes that there is a certain symmetry between the generation of metals and plants, and although he has his own autopsia to go on, or the ersatz autopsia of his gardener, combined with the authority of van Helmont, to aid him in arriving at a plausible mechanism on plant growth, he must accept the accounts of authority figures in arriving at an understanding of the growth of metals. It does seem that when the mechanism of growth for both plants and metals can be reconciled, Carneades takes extra assurance in his search for an understanding of the production of growing things.

It seems to be the case that Carneades accepts the reality of the transmutation of water, plus seminal principle, and earth guided by a metallic principle, into plants and metals, respectively. The origin of minerals may lie somewhere between the two – with water as the element which is transmuted into minerals when acted upon by some unspecified agent. He seems to be most influenced by van Helmont in his thinking on plant growth, and the latter's insights, combined with his own efforts and those of his reliable gardener, seem to be sufficient to his needs in devising an effective hypothesis on the subject. Aristotle, though only partially acknowledged, along with trusted observations, seems to have informed his thinking on the growth of both minerals and metals.

Further evidence of the possibility of earth undergoing transmutation into minerals is provided by the production of saltpetre, nitre, or potassium nitrate, which grows as a white crystalline solid on decaying organic matter exposed to the air. It was a very important mineral since at least the Middle Ages, as it was employed in the production of gunpowder, and also in preserving food, being produced in quantity by 'Boylers of Salt-Petre' (364.20-21). These men 'unanimously observe, as well here in *England* as in other Countries' (364.21-23) that if earth containing saltpetre has this mineral washed out of it with water, the earth 'will after some years yield them Salt-Petre again' (364.26-27). Carneades is describing here the production of a mineral by the application of a standard procedure. The water used to dissolve out the nitre from the parent organic material could be heated to reduce its bulk, and when cooled the saltpetre would crystallise out as a white solid. Unlike most mineral formation, the growth and preparation of this mineral takes place in the open air, so that one could monitor the development of the mineral on the decaying organic matter over time, and as its production involves the use of simple laboratory procedures: washing, boiling, crystallisation, Boyle could well appreciate how the harvesting of the salt was effected. When his claim that the occurrence of saltpetre was 'unanimously' (364.21) observed, is added to this, it was an easy matter for him to accept these workmen as reliable figures of authority. His description of some of them as the 'eminent and skillfullest' (364.28) of their kind indicates Boyle's respect for them and their expertise.

Another example of Boyle trusting the reports of another is provided by an account given to him by 'a person of Great Credit' (365.16-17) and skill in the production of the mineral, informed him of the behaviour of 'Vitriol [iron sulphate]' (365.18), when pyrite, iron pyrites or iron sulphide, is oxidised to iron sulphate through the agency of atmospheric oxygen. Carneades relates that he obtained a 'certain kind of Merkasite' (365.28), which is chemically identical to iron pyrites, but occurs in a different crystal system. He found that in a few hours, in his chamber, it began to turn into vitriol or iron sulphate. This adds credence to what he has just related 'that we need not distrust the newly recited narrative' (366.3-4). In the case of the production of vitriol, Carneades has his personal autopsia, which when considered along with the information related to him by a competent witness, enables him to adopt a completely reliable account of the production of this mineral.

Carneades reverts to discussing a topic over which he deliberates throughout much of *The Sceptical Chymist*, namely the alleged powers of van Helmont's *alkahest* or universal solvent. He sets up his argument by imagining the case in which the extravagant claims, made by van Helmont for his powerful solvent, are accepted as valid by both Carneades and the chemists. He argues that they could 'press [force] me with his Authority concerning them, and to alledge that he could Transmute all reputedly mixt Bodies into insipid and meer [pure] Water' (390.6-10).

Carneades believes that the chemists have a right to ask him for his justification for accepting the authority of van Helmont on the matter. He will, however, put it to the chemists or Paracelsians that though van Helmont's 'Affirmations conclude strongly against the Vulgar Chymists' (390.11-13), and against whom Carneades is willing to employ them, since these same affirmations prove that the putative principles or ingredients of which things are constituted, are not truly elemental, as these can be ultimately reduced to 'Insipid Phlegme differing from them all' (390.19-20). If van Helmont's doctrine is accepted as authoritative, it implies that the *tria prima* of the Paracelsians are not true principles, as all of them can be reduced to water.

However attractive this notion may be to Carneades, evidence in favour of one doctrine is evidence against another which is opposed to it, yet Carneades is not yet willing to accept the claims made by van Helmont in relation to his *alkahest*. Despite the authority he invests in van Helmont, his own autopsia would need to be satisfied if he were to believe those claims, and he objects that 'till we can be allow'd to examine this Liquor, I think it not unreasonable to doubt whether it be not something else then meer [pure] Water' (390.20-23). The reason for Carneades' doubting is that van Helmont does not actually claim that the liquor in question is water: his claim is that it is 'insipid' (390.26). Being insipid Carneades counters is not necessarily confined to water, and is an 'Accident or an Affection' (390.27) of the mouth rather than a primary quality inherent to materials. He hypothesises that it may be that a bland taste may be the sensation felt in the mouth by a substance whose microparticles are not sufficiently angular or large to 'make a perceptible Impression upon the Nerves or Membranous parts of the Organs of Tast' (391.5-8), and such a liquor may not necessarily be water. He reminds his companion that 'the best sort of Oyle-Olive is almost tasteless' (391.25-26), yet not at all aqueous in nature, and mentions that some other substances, including mercury, are tasteless. Carneades reasons that the end result of a chemical reaction may be the production of an insipid liquor, but that this is no proof that it is water, thereby casting doubt on van Helmont's claim about the capacity of his *alkahest* to reduce all materials to water.

Part of Carneades' doubting the powers of van Helmont's *alkahest* is on account of the properties attributed to it being so extraordinary as to be scarcely credible. He stipulates that the 'Effects ascrib'd to that power are so unparallell'd and stupendious, that thought I am not sure that there *may be* such an Agent, yet little less than αὐτοψία seems requisite to make a man sure there *is*' (473 [427].16-17 – 428.1-4). This is Carneades' most explicit statement on the relative importance of authority and autopsia in the assessment of knowledge claims regarding the physical world. He may have it on the authority of a chemist he holds in the highest esteem – van Helmont – and does not flatly deny that the renowned savant's claims regarding his *alkahest* may be valid, yet nothing less than practical experimentation can put the matter to the test. The truth of van Helmont's assertion can only be established by autopsia, and at this stage in Boyle's experimental career, no definitive conclusion on the subject has been reached.

Clarity and Distinctness

Throughout *The Sceptical Chymist* Boyle stresses the importance of clarity, and its cognates, in the successful investigation of the natural world. He employs the word in two senses: the first is in the Cartesian sense, the second in the sense of lucidity of expression in speech or writing. Throughout many of his works he acknowledges his respect for, and admiration of, Descartes, and an obvious example of his indebtedness is provided by Boyle's application of the notion of clarity of apprehension as a marker of truth, as stated in the Fourth Meditation of Descartes' '*Meditation on First Philosophy* – of the true and the false'. This meditation stipulates that when one *clearly and distinctly* perceives a conception one can be assured of its truth, for such a conception is, without doubt, something. Conversely, one should abstain from giving one's judgement on something when ones does not perceive it with sufficient clearness and distinctness, for things which are understood confusedly and obscurely cannot lead to the truth. Boyle makes skilful use of Descartes' precept in examining knowledge claims in relation to the created world.

Curiously, in her essay on Boyle's early version of *The Sceptical Chymist*, Boas says of this work that it shows no trace of Cartesianism, and this does indeed seem to be the case, as terms such as 'clear and distinct', 'clearly' and 'clear' are absent from this earlier text.[3] The evolution of Boyle's attitude towards some of the writers, including Descartes, who were later to influence him, may be gauged from his saying in his 'Proëmial Essay' from *Certain Physiological Essays*, and published in the same year, 1661, as *The Sceptical Chymist*, when he acknowledges that 'the Learned *Gassendus* his little *Syntagma* of *Epicurus'* Philosophy, and that most ingenious Gentleman *Mon*^{r} *Des-Cartes* his Principles of Philosophy. For though I purposely refrain'd, though not altogether from transiently consulting about a few Particulars, yet from seriously and orderly reading over those excellent (though

[3] Marie Boas, 'An Early Version of Boyle's: Sceptical Chymist', *Isis* 45, no. 2 (1954) 153-168, 156.

disagreeing) Books, or so much as Sir *Francis Bacon's Novum Organum*'.[4] Yet a few lines later he acknowledges that he is 'yet beginning now to allow my self to read those excellent Books'.[5]

He put the influence of Descartes to good use in countering the objections put forward by Hobbes in his denial of the reality of the vacuum generated in Boyle's air pump, and published at about the same time as *The Sceptical Chymist*. Boyle rejects Hobbes's argument by challenging anyone:

> that would undertake to settle a general Theory of the Notion of Restitution, the *clear* and *Distinct* [italics added] Explication of several *Phaenomena* that I had met with, which are not touch'd, nor perhaps were, some of them, thought upon by *Mr. Hobbs*.[6]

Boyle further dismisses Hobbes's objections to his claim regarding the vacuum when he asserts:

> Nor is what he adds concerning the *Vacuum* to be attributed to *Democritus* and *Epicurus* either *clear* [italics added] enough, or of concernment enough to our Dispute, to be insisted on by us, especially since I see not what purpose he brings in it.[7]

In *The Sceptical Chymist* Boyle employs the word 'clear' and related words, in is consideration of the knowledge claims made by his Paracelsian adversaries, whose comprehension of both the workings of the human body and of many of the phenomena of the natural world is impaired by their desire to see all natural phenomena in terms of their *tria prima* of salt, sulphur and mercury. Boyle puts them on notice that not only will the chemist, Carneades, offer objections to this doctrine, but that the explanatory power of his own Corpuscular Philosophy is such as to warrant careful consideration by them. He advises them that 'there are a

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[4] Michael Hunter and Edward B. Davis, eds. *The Works of Robert Boyle*, 2: 12-13.
[5] Ibid., 13.
[6] *Works of Robert Boyle*, 3: 123.
[7] Ibid., 160.

thousand Phaenomena in Nature, besides a Multitude of Accidents relating to the humane Body, which will scarcely be clearly & satisfactorily made out by them that confine themselves to deduce things from Salt, Sulphur and Mercury, and the other Notions peculiar to the Chymists' (A2r.29 – A2v.1-5).

A contrast between what Boyle considers as clear and what his Paracelsian adversaries hold to be so is provided by 'that known Chymical sentence; Ubi palam locuti sumus, ibi nihil diximus (A3r.16-18) [where we have clearly spoken, there we say nothing]. Of course Boyle believes that smoke hides rather than reveals, and that the smoke generated in the combustion of organic materials or during chemical reactions discloses little of what is occurring at the most fundamental level of those materials. This provides him with a telling metaphor for the distinction between the knowledge claims made by the Paracelsians and himself: if the clearest expression of their understanding of a material's composition or behaviour is to be had from observations made of the smoke generated during the thermal manipulation of such materials, it says little for their ability to comprehend and explain the events taking place within them, and to provide an accurate account of these events.

Boyle, with a certain irony, allows the idea of clarity to be spoken of by the Aristotelian dialogist, Themistius, who defends his notion of the true nature of matter as expressed in the elemental system of the Aristotelians. He eschews the use of experiments, thereby turning Boyle's own doctrine on its head, confining their use to 'those that are not capable of a Nobler Conviction' (20.24-25), indicating that for him experiments are for those of inferior powers of apprehension who, unable to grasp the validity of rationally deduced truths of nature, must content themselves with resorting to practical means of investigation. Of course, included in their number is Carneades, who has been included by implication among the hapless individuals possessed of only limited intellectual faculties. Themistius wryly manages another side-swipe at Carneades by speaking of his kind as having to ‘descend’ (20.29) to the level of those who ‘must be taught by their senses’ (21.1-2), thereby passing negative judgment on the merits of sense-data in arriving at knowledge of the natural world. Combining his subtle dismissal of experiment and of sense perception as means of arriving at real knowledge of creation, he implies that Carneades is among those who fall back on such means ‘for want of being arriv’d to a *clear* [italics added] apprehension of purely Matematical Notions and Truths’ (21.2-4).

In allowing one of the dialogists to take a critical stance on Boyle himself and of his philosophical position, Boyle may be letting it known that both his Corpuscular Philosophy and its author are not above criticism and negative comment. Self deprecation delivered in an ironic, humorous manner may be his best defence against the claim that *The Sceptical Chymist* is an unrelieved diatribe against the accounts of matter with which he disagrees.

Themistius makes the case, pointedly, that the Aristotelian doctrine of the four elements, having been explained by him in practical terms by observing the combustion products of green wood, fulfils the requirement for an ocular proof of this doctrine. It is, in addition, he says ‘as *clear* and *intelligible* [italics added] to the Understanding as obvious to the sense’ (22.25-27). It is no wonder, he adds, that a teaching which offers so much conviction to both the senses and the intellect should have been accepted for a very long time by ‘the learned part of Mankind’ (22.27-28). This may well represent an attempt by Boyle to reassure his well-informed readers that he understands why so many of the scholarly class do see both a rational and experimental basis to the Aristotelian doctrine, being acutely aware that he may speak disparagingly of teachings he opposes, without acting in a condescending or slighting manner towards those who hold them. Themistius rounds off his contribution by invoking a Cartesian image to assert how, to his mind, principles ought to be: they ‘ought to be like Diamonds, as well very *clear*, [italics added], as perfectly solid’ (25.7-9).

Boyle reverts to his more usual practice of challenging the validity of the Paracelsians’ *tria prima* by drawing attention to a case where a given decomposition product cannot have one principle only assigned to it. He argues that some plants and animals yield strongly scented oils when distilled, in fact he maintains that such oils cannot be separated into a purely odourless product. The existence of this odorous liquor contradicts the Paracelsian’s claim that strongly smelling materials are predominantly saline, as these liquors, being inflammable, are clearly predominantly sulphurous in nature. Such an oil, he avers ‘does not *clearly* [italics added] Evince [prove] so much as the presence of the saline Principle in it’ (246.12-14).

This time the lack of clarity arises from the demonstrable inability of the chemist, employing the laboratory techniques and equipment available to him, adequately to produce a fraction of liquor which would indubitably produce a separated product which was odorous, hence saline, without being oily, and therefore sulphurous. So long as such a separation is not achieved one cannot assign an odorous, inflammable product to one principle only.

Another perspective on clarity is offered not by the putative sceptic, Carneades, but rather by the neutral Eleutherius, in his capacity as moderator of the dialogue, regarding an argument which Sennert postulates in relation to the presence of a spirit in all bodies, in addition to other elements. Carneades rejects this belief on the grounds that to accept it would be for him to assent to a mystical doctrine.

However, Eleutherius counters this by arguing that the doctrine in question does appear clear to those who acknowledge the Paracelsian *tria prima*, and he ventures to suggest that if he adopted Sennert's view-point 'the same thing would be thought *clear* [italics added] by me, and those that are fond of such cloudy Expressions as You justly Tax the Chymists for' (269.17-20). He then goes on to give his rationale as to why he would do so. In this exchange Carneades makes it known that he cannot accept this doctrine, despite his great admiration for Sennert. What Eleutherius draws attention to is that an explanation which arises out of a particular doctrine may be intelligible only to those who accept that doctrine, and that those who do not accept the doctrine will not accept any explanation which presupposes its validity. Eleutherius explains that a given account may seem clear to those who take a particular perspective on the principles, yet may seem obscure to those who do not accept these same principles. Having done so, he goes on to propose a particular point of view on the question which will enable his fellow dialogist to better understand the original Sennertian doctrine.

Eleutherius elaborates his point to the extent that at the end of his explanation he suggests to his companion that there is a rationale behind Sennert's teaching on the subject by recommending that his use of the term 'spirit' might be preferable after all. He explains that he 'would substitute to the too much abused Name of Mercury, the more *clear* [italics added] and Familiar Appellation of Spirit' (270.2-4), as a term which the chemist themselves commonly employ. Here the term 'clear and Familiar' has the connotations of 'spirit', being more comprehensible as a product to the practitioners of chemistry than the term 'mercury'. He may here have in mind that a volatile, fugitive product would better deserve to be called spirit than mercury.

However, being able to apply the generic term spirit to a component fraction of a thermally decomposed material is one thing, defining what this term actually means, is another. Eleutherius draws attention to this point when he acknowledges that the chemists have not provided 'so Distinct an Explication, as were fit, or what may be call'd the Spirit of a mixt Body' (270.8-10). Natural bodies are constituted of physical ingredients, so what then, constitutes the spirit of such a body?, and here Eleutherius may have put his finger on the nub of the issue, as substituting the term 'spirit' for 'mercury' does not add any further clarity to what these words signify, if mercury refers to an ingredient of compound bodies, unless it is understood precisely what it actually refers to. Substituting the term 'spirit' will not add any further clarification as to what 'mercury' actually is, and if mercury forms part of a mystical doctrine, as Carneades has already complained it does, substituting one rather obscure term for another will not make that doctrine any less mystical.

Carneades makes a negative comment on the writings of Paracelsus, accusing him of writing unintelligibly whilst at the same time conceding that he has ‘father’d upon such excellent Experiments’ (429.17-18) of which Carneades acknowledges ‘I often find he knew’ (429.19-20). Yet it is Paracelsus’ writings, which so often he ‘puzzels and tyres his Reader with’ (429.17) which Carneades finds objectionable, and protests ‘as though he seldom *clearly* [italic added] teaches’ (429.19). Excellent though some of his experiments may have been, Carneades condemns him for his inability to employ his practical investigations of matter in constructing an intelligible explanatory system. It is implied, though unstated, that those excellent experiments for which he praises Paracelsus are reported with due clarity by him, otherwise Carneades would not have been able to recognise them for what they are. Yet he remains critical of Paracelsus in considering that the clearness of the accounts of his practical endeavours did not transfer into the construction of an equally lucid explanatory system.

Eleutherius now acknowledges that ‘divers of the Experiments you have mention’d are no secrets’ (430.17-19), implying that some at least of the experiments mentioned by Carneades as having been carried out by Paracelsus were common knowledge among experimenters. Yet the crucial difference between Carneades and the other experimenters, including Paracelsus, is that they were added to by Carneades, then arranged and applied in such a way that he ‘made such Deductions From them, as I have not Hitherto met with’ (430.24-26). It is how Carneades made good use of his experiments to reinforce his understanding of the natural world, which Eleutherius praises, something which Paracelsus, among others, failed to do.

Finally, Carneades discusses the opinion of *Anthonius Guntherus Billichius*, which posits that compound bodies not only are constituted of, and are decomposable into, the four Aristotelian elements, but that each of the *tria prima* consists of the same four Aristotelian elements. He notes that ‘in the *Tria Prima* themselves, whereinto Chymists are wont to resolve mixt Bodies, each of them *clearly* [italics added] discovers it self to consist of four Elements’ (315.27-29 – 316.1). From the context of the foregoing it is evident that the one to whom each Paracelsian principle clearly discovers or reveals itself to consist of the four Aristotelian elements, is *Guntherus* himself, yet it is a doctrine reported by Carneades and subsequently critiqued by him. Nevertheless Carneades acknowledges that the presence of the four Aristotelian elements in each of the Paracelsian *tria prima* is clearly obvious to one writer, *Guntherus*, even if Carneades himself does not accept this interpretation of the composition of mixed bodies.

Boyle’s use of Humour

It could be argued that Boyle employs humour in his text to serve a triple purpose: the first is to add a touch of levity to what can otherwise be a somewhat tedious narrative; the second is to undermine his adversaries’ opinions and diminish them in the eyes of the well-informed readers he strives to convert to his Corpuscular Philosophy; the third is to warn or alert his readers to practices which may be employed against them by the Alchemists or Paracelsians, by his use of a subtle humour or lightness of touch, so as not to cause offence to those whom he is anxious to influence, as they themselves may be drawn towards those rival theories.

An example of Carneades railing indignantly at the narrowness of the explanatory power of Paracelsus' *tria prima* occurs on page 301 of the text. He complains that a philosophy which treats of materials to be found only in the crust of the earth and its atmosphere, and which constitute no more than a small proportion of the universe, is of little use to us. At least the Aristotelian doctrine of the four terrestrial, and one celestial, elements could provide an explanation for the composition of the entire cosmos. Yet Paracelsus himself is believed to have held that not only the four Aristotelian elements, but even the heavenly bodies themselves, are composed of his *tria prima*. Carneades passes swift judgement on this belief by concluding tartly that: 'since the modern Chymists themselves have not thought so groundless a conceit worth their owning, I shall not think it Worth my confuting' (301.5-9).

Earlier in the text, Carneades, in referring to his adversary's argument, invited Philoponus 'to make your Reasoning cogent' (29.3-4). A short while before this he tells Philoponus that he would accept that his argument proved something only if we could see nature reach up almost to the moon and 'pull down a parcell of the Element of Fire' (28.23-24), 'and to blend it with a quantity of each of the three other Elements, to compose every mixt Body' (28.26-29). Of course Philoponus or Themistius could counter that, although fire's natural place, in Aristotelian cosmology, lies just below the orbit of the Moon, nevertheless it would be absurd to contend that fire can only be obtained by reaching Prometheus-like up to the space beyond the upper reaches of the atmosphere, capturing a portion of fire, and dragging it down to earth. Fire could be considered as a constituent of all material bodies, and only when it is released from these bodies, by strong heating or burning, does it seek its natural, sub-lunar, place.

Boyle cannot disprove the Aristotelian hypothesis on the four elements, but he can hold it up to ridicule in the eyes of the sophisticated readers he is attempting to win over to his scheme of things. Indeed, he doubtless has a more serious purpose, in that he is planting seeds of doubt in the minds of his readership as to how fire comes to be obtained or generated, and once made available, blended with the other three elements.

Boyle maintains his relentless assault, through Carneades, on the doctrines, not just of the Paracelsians, but of the Aristotelians as well. Carneades sneeringly remarks that the Paracelsians do deserve some praise for their rejection of the Aristotelian theory of the four elements. He says ‘And for this Rejection of a Vulgar Error, they ought not to be deny’d *what praise men may deserve* [italics added] for exploding a Doctrine whose Imperfections are so conspicuous, that men needed but not to shut their Eyes, to discover them’ (327.7-13). Exactly how much praise such men deserve, Carneades does not stipulate, though they can hardly be worthy of very much of it if all they can manage to do is to point out what is obvious to all sighted people.

However, Carneades does not credit the Paracelsians with anything but the dimmest of perspicacity when he remarks drolly that they cannot see that they also must ‘have Recourse to more Fruitfull and Comprehensive Principles then the *tria Prima*, to *make out* [italics added] the Properties of the Bodies they converse with’ (327.16-19). They can see perfectly clearly, along with all who have the sense of sight, what is wrong with the Aristotelian doctrine, yet Carneades is scornful of them for being unable to perceive how inadequate their own *tria prima* are in explaining the properties of the materials they study.

Boyle can also put humour to less caustic, though no less effective, use when he argues the merits of two materials which he does sometimes regard as elemental – earth and water. His argument is that they are denied elemental status by the Paracelsians. He cleverly makes his point by positing that the utility of earth and water resides solely in relation to how we judge them relative to ourselves. He makes a witty comparison by positing that the 'hurtful Teeth of Vipers' (189.26) are of no value to us, yet they constitute a useful part of the snake's anatomy. Turning his attention towards the wider cosmos, Carneades remarks that the white patches of the sky are resolved by telescopes into hitherto unknown stars, of no utility to humans, yet undeniably an intrinsic part of the universe.

The Bible was never far from the thoughts of Boyle, a devout Christian, and this time serving an anatomical analogy concerning the human body. Earth and water are not as operative, he contends, as the three other, more active, principles, yet he recalls the 'lucky Fable of *Menemius Aggrippa*, of the dangerous Sedition of the Hands and Legs, and other more busie parts of the Body, against the seemingly unactive Stomack' (186 [190].20.24). He adds to this a Biblical quotation:

> *If the Ear shall say, because I am not the Eye, I am not of the Body; Is it therefore not of the Body? If the whole Body were Eye, where were the Hearing? If the whole were for hearing, where the smelling?* (186 [190].27-29 – 187 [191].1-3).

Carneades humorously, yet thoughtfully, insinuates the notion of Biblical sanction along with a connection to the Ancient World, to his, for the most part, believing, classically trained readers, simply by linking his opinion of the true utility of earth and water with a striking New Testament allusion, following on from one drawn from the Roman world.

A comparison drawn from the Old Testament forms part of yet another verbal assault on his Paracelsian adversaries, when he likens their searches after truth to 'the Navigators of *Solomons Tarshish* Fleet, who brought home from their long and tedious Voyages, not only Gold, and Silver, and Ivory, but Apes and Peacocks too' (429.22-26). So too with the Alchemical writers who, as well as experiments of value, present 'Theories, which either like Peacocks feathers make a great shew [show], but are neither solid nor useful' (430.1-4). Their experiments, Carneades acknowledges, are sound and useful, but the theories they build from these are no more substantial than the display feathers of a peacock's tail. Apart from creating a striking and memorable image of theories as being mere ostentation, he is no more than poking fun at such theories for their lack of content. He goes on, however, to say that alternatively, instead of being peacock-like, the Alchemical theories are 'like Apes, if they have some appearance of being rational, are blemish'd with some absurdity or other' (430.4-6). Here Carneades is turning on his adversaries and making a more substantial criticism of them by asserting that the content of their theories is such as to be no more than having the appearance of rationality, but which, when carefully reflected upon, 'makes them appear Ridiculous' (430.8-9).

This is Carneades' final contribution to the debate on the *tria prima*, and the constituency to whom he intends these to seem laughable are the sober, thoughtful readers whom Boyle is endeavouring to win over to his Corpuscular Philosophy, with its systematic, rational interpretations of the experiments which Carneades narrated throughout *The Sceptical Chymist*.

Carneades begins *The Third Part* of the dialogue with his stated intention to consider the experiments which the chemists have carried out and in which he derisively avers that ‘they are wont so much to Triumph and Glory’ (166.2-3) which experiments are advanced by their proponents with ‘so much Confidence and Ostentation’ (166.7), and imposed upon their readers or audience. Carneades conveys an impression of such men as illusionists or charlatans who present exotic laboratory feats to the gullible, with supreme confidence, conviction and panache. So great is their self-belief that many, who perhaps ought to know better, are won over. Those with whom they come in contact fall into three categories: some simply accept the boastful claims rather than test them for themselves; some men have the curiosity to examine their claims but lack the opportunity and competence to do so. It is the third and largest group of men, including the well-informed, who are deluded the most, and Carneades, wishing also to have a side-swipe at the Scholastic Philosophers, by disdainfully remarking that the chemists are not content to leave it to the ‘Schools’ (166.23) to entertain the readers of natural philosophy with vacuous explanations, but must themselves add to their amusement by making unsubstantiated, though confident claims regarding the separation of elemental ingredients. So secure are they in their beliefs that even the well-informed are duped into thinking that it is reasonable to take such ‘experts’ at their word, and thereby are deceived by their claims.

Boyle, mindful of those whom he is hoping to convert to his Corpuscular Philosophy, is employing a certain levity or lightness of touch, by which he simultaneously attempts to undermine the specious claims, as he sees it, of both the Scholastic Philosophers and the Paracelsians, whilst alerting the learned to the fact that they are being hoodwinked by the convincing yet empty rhetoric of a cohort of supremely confidant practitioners of alchemy. He must negotiate a fine line between subjecting his Paracelsian and Scholastic adversaries to ridicule, and avoiding criticising those whom he is attempting to influence, by maintaining that the educated make the plausible judgement that men who speak with great conviction and (apparent) knowledge have every appearance of credibility. He patiently reminds his scholarly readers, with a subtle humour, that they are being fooled into accepting blatantly false knowledge claims by unscrupulous Paracelsians.

Boyle is not above poking fun at himself in an oblique kind of way as when, early on in the dialogue, Themistius, the Aristotelian, offers a scathing criticism of the Paracelsian doctrine, as professed by his fellow dialogist, Philoponus. Themistius, not much given to experiment, accuses Paracelsus of having denied the longstanding Aristotelian theory of the elements and replacing it with his own *tria prima*. He rails, indignantly, that these self-styled philosophers are, in fact, no more than 'sooty Empiricks' (24.2), 'having their eyes darken'd, and their Brains troubl'd with the smoke of their own Furnaces' (24.4-6). The unstated implication is that if one doctrine came about as a consequence of impaired judgement on the part of chemical practitioners, then maybe a second one also – Boyle's own Corpuscular Philosophy – may have emanated from the equally impaired brain of the committed experimenter, Boyle himself.

Of course Boyle is doing no more than presenting a widely-held criticism of his own opinion on the necessity to investigate the workings of nature by experimental means, a criticism shared by his Aristotelian adversaries. He chooses to do so, not by having his own spokesman, Carneades, taken to task for his belief in the need for experiment, but rather by poking fun at a fellow experimenter, and one professing an alternative doctrine to his own, and in so doing indirectly subjecting to challenge Boyle's understanding of the importance of experiment.

Conclusion

The Sceptical Chymist may be considered as a transitional work which was written at a time when the systems of both Aristotle and Paracelsus were coming under real attack from corpuscular chemistry, which tendency would continue into the future as corpuscles gave way to atoms and modern atomic chemistry came into being. The irresistible momentum of this process was already under way in *The Sceptical Chymist* when the qualitative explanation of phenomenal change yielded to Boyle's quantitative understanding of it, where corpuscular identity was conserved throughout change.

An effort has been made to explain *The Sceptical Chymist* to the reader in a wider context than a simple commentary. To this end the Literature Review and Discussion were prepared with the intention of explaining the perceptions of and insights into the work by various reviewers over a time scale spanning several decades so that the reader might have a better understanding of the book. The Discussion is concerned with drawing out some of the themes running through *The Sceptical Chymist*, and in light of these to view the work from a deeper perspective than that provided by the Commentary alone.

It could be argued that a guiding precept should be that commentary has more to do with elucidating the primary text by way of exposition, explanation and information than with offering opinions on it. It is hoped that with the present commentary the author has remained self-effacing throughout – perhaps with occasional lapses – and has focused on bringing to light, and to life, what Boyle has said, rather than on venturing opinions on either the Honourable man himself, or on his text.

Suggestions for Further Research

In the course of writing this project some ideas worthy of consideration have arisen, but which are not of immediate relevance to the production of this commentary, including the following:

Boyle on mixing

One subject obviously deserving of further attention is Boyle's critique of Aristotle's account of mixing, and how it compared with that of some other Greek thinkers, and with Boyle's own understanding of the subject, as expressed in *The Sceptical Chymist*.

Boyle on water and earth

His fascination with water, due to its position (with earth) as a primal matter in the Biblical account of creation, its elevated status in early Greek thought, and its positing as a primal substance by van Helmont, meant that Boyle always regarded it, along with earth, as occupying a privileged position in his scheme of created things. This subject is worthy of further investigation.

Boyle and Higgins on the development of the Atomic Theory

Boyle's adoption of an atomistic theory – his Corpuscularian Philosophy – was part of a process that led from the Ancient Greeks, through the Middle Ages, to the revival of the Atomic Theory *per se* by Gassendi, to the further development of the theory by John Dalton in the early 1800s. However, two important stages in this development were due to Boyle in the mid- to late- seventeenth century and to

William Higgins in his publishing of his Atomic Theory in 1789. An investigation into the connection between Boyle's Corpuscular Philosophy and Higgins's Atomic Theory would surely prove to be a worthwhile study.

BIOGRAPHICAL INFORMATION

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The Dialogists: Carneades, Eleutherius, Philoponus and Themistius.

The names that Boyle chooses for his interlocutors are 'not arbitrary', and 'some further insights are to be gleaned by a consideration of them'.[1] They are also briefly mentioned elsewhere.[2] At least some of these names, including Carneades', have appeared in some other Boylean dialogues.[3]

Carneades. The historical Carneades (214-129 BCE) a Sceptic philosopher, was born in Cyrene, North Africa, and migrated to Athens where he served as Scholarch of the Academy from 167-137 BCE.[4] Under his direction the Academy remained sceptical, and he himself developed further sceptical arguments. The difference between Academic and Pyrrhonist scepticism has been defined by Thorsrud as:

> The Academics apprehend (in some sense) the very fact that nothing can be apprehended, and they determine (in some sense) that nothing can be determined, whereas the Pyrrhonists assent that not even that seems to be true, since nothing seems to be true.[5]

He categorises the Sceptics, both Academic and Pyrrhonist, as:

> *skeptikoi* (those who investigate),
>
> *ephektikoi* (those who suspend judgement), and
>
> *aporētikoi* (those who are puzzled).[6]

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[1] Principe, *The Aspiring Adept*, 73.
[2] Hunter and Davis, *Works of Boyle*, 2:28, note c.
[3] For which see Literature Review, Part 2, Maia Neto and Pereira Maia, *Boyle's Carneades*.
[4] *Routledge Encyclopaedia of Philosophy*, 10 vols. Edward Craig, gen. ed. (London: Routledge, 1998), 2:215.
[5] Harald Thorsrud, *Ancient Scepticism* (Stocksfield: Acumen, 2009), 8.
[6] Ibid., 7.

It could well be argued that all of the above can be applied to Boyle's Carneades, as he both investigates the behaviour of matter in his laboratory experiments, whilst at the same time suspends judgement, sometimes on the outcomes of his own experiments, but more often on the opinions of his adversaries; frequently he expresses puzzlement at the justifications advanced by them in relation to their interpretations of materials' compositions, dispositions and behaviour.

The historical Carneades wrote nothing, and even the lecture notes of his pupils have been lost. Of course Boyle's Carneades did not record the unfolding dialogue of *The Sceptical Chymist*: that task was left to Boyle himself, present throughout as a silent note-taker. The philosopher Carneades was famously eloquent, being possessed of a remarkable capacity to stir his audience: his Boylean counterpart is well able to hold centre-stage for the duration of the discussion.

Eleutherius. Although a number of historical figures bear this name, Boyle obviously chose it from the Greek word ἐλευθέριος which has the meanings:

> speaking or acting like a freeman, free-spirited, frank. Freely giving, bountiful, liberal. Of pursuits, fit for a freeman, liberal. Of appearance, free, noble.[7]

In *The Sceptical Chymist* Eleutherius certainly lives up to this definition in that he is freely giving of his opinions. He is free in so far as he does not espouse any particular doctrine or system, and he is frank – sparing no doctrine from scrutiny. Eleutherius displays a quality of nobility, manifesting a tone of haughty courteousness throughout the discussion.

[7] Liddell and Scott, *An Intermediate Greek-English Lexicon*, 249.

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Philoponus. This name means:

> Loving labour, laborious, industrious, diligent,[8]

and was no doubt chosen by Boyle to reflect the qualities of hard work and dedication applied to their chemical pursuits by the Paracelsians. The name Philoponus is a nickname given to various philosophers because of its literal meaning: 'lover of work'.[9] The one with whom this name is usually identified is John Philoponus, John the Grammarian, Johannes Philoponus, Johannes Grammaticus (*c*.490 – *c*.570) of Alexandria, a Christian philosopher, theologian and literary scholar.[10] He 'engaged on a sustained, two-pronged attack on Aristotelianism, criticising many of the central theses of Aristotle's physics both on the grounds of inconsistency and on the grounds that they fail to fit the facts'.[11] It is likely that Philoponus' opposition to Aristotle was an important factor in Boyle's choice of 'Philoponus' as the dialogist who represented a view of the natural world that was contrary to that of Aristotle. The historical Philoponus influenced subsequent scientific thought to Galileo's time by supplanting many of Aristotle's beliefs with an account centred on the Christian idea that the universe had an absolute beginning.[12]

Themistius. The historical Themistius (*c*.317 – *c*.388 CE), was born in Paphlagonia, and although a pagan, he acted as an adviser to Christian Roman emperors. He 'aimed

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[8] Liddell and Scott, *An Intermediate Greek-English Lexicon*, 864.
[9] Richard Sorabji, *Philoponus and the Rejection of Aristotelian Science* (Ithaca: Cornell University Press, 1987), 5.
[10] *Encyclopaedia Britannica, Micropaedia*, 10 vols. (Chicago: Benton, 1976), 7: 951.
[11] G.E.R. Lloyd, *Greek Science after Aristotle* (London: Chatto & Windus, 1973), 158.
[12] Simon Hornblower and Anthony Spawforth, eds. *The Oxford Classical Dictionary*, 4th ed. (Oxford: Oxford University Press, 2012), 1135.

at making the celebrated writings of his heroes Plato and Aristotle more accessible through explanatory paraphrase'.[13] In the Middle Ages he was considered an important epitomiser of Aristotle. He was a philosopher, orator, politician as well as imperial adviser.[14] '[T]here survive five paraphrases of works of Aristotle'.[15] He always regarded himself primarily as a philosopher, with oratory almost as important. 'Themistius believed that the truths of philosophy needed to be broadcast widely and that rhetoric was the chief instrument for accomplishing this'.[16]

Three Atomists: Leucippus, Democritus and Epicurus

Leucippus of Miletus or Elea[17] (*fl*. 450-420 BCE),[18] 'was undoubtedly responsible for the foundations of the atomic theory, but there is little evidence that he made any attempt to apply the doctrine in detail to explain natural phenomena'.[19] 'The basic postulate of ancient atomism in its original, fifth-century form was that atoms and the void alone are real'.[20] 'Like the one unchanging being of the Way of Truth, each individual atom is ungenerated and indestructible, unalterable, homogeneous, solid and indivisible'.[21] 'Leucippus may have thought the atoms indivisible because they are so

[13] *Routledge Encyclopaedia of Philosophy*, 9:324.
[14] Ibid., 324.
[15] Peter Heather and David Moncur, trans. *Politics, Philosophy, and Empire in the Fourth Century. Select Orations of Themistius* (Liverpool: Liverpool University Press, 2001), 1.
[16] Robert J. Penella, "The Rhetoric of Praise in the Private Orations of Themistius", in *Greek Biography and Panegyric in Late Antiquity*, ed. Tomas Hägg and Philip Rousseau (Berkeley: University of California Press, 2000), 194.
[17] Philip Wheelwright, ed., *The Presocratics* (New York: Macmillan, 1966), 180.
[18] Simon Blackburn, *The Oxford Dictionary of Philosophy* (Oxford: Oxford University Press, 1994), 216.
[19] G.E.R. Lloyd, *Early Greek Science Thales to Aristotle* (London: Chatto & Windus), 48.
[20] Ibid., 45.
[21] Ibid., 46.

small, "without parts (ἀμερῆ)"[22] not because they are infinitely hard, as Demokritos assumed'.[23]

None of the works of Leucippus has survived, as 'They were engulfed in the surge of disapproval generated by the great Athenian schools. Our knowledge of them depends on quotations in surviving authors, criticisms by their rivals, and summaries by the ancient historians of philosophy',[24] with one book, *The Great World Order*, attributed to Leucippus by the Theophrastian School.[25]

'Leucippus concurred with the Eleatic argument that true being does not admit of vacuum and that without vacuum there can be no movement; but starting out from the more realistic assumption that movement does in fact exist, he contraposed the argument – contending that since movement exists there must be vacuum, but that since vacuum cannot really *be* it must be identified with non-being'.[26]

Democritus of Abdera (*c*.460 – *c*.370 BCE)[27] is best known for his atomic theory which he extended and developed from the original expression of the doctrine by Leucippus, who remains a more obscure figure than Democritus. The paucity of evidence makes it difficult to establish how much Democritus added to Leucippus' doctrine; what is clear is that he managed to add to the atomic doctrine's fame and to cause it to become a

[22] Liddell & Scott give this word as ἀμέρής, meaning: without parts, indivisible. See: Liddell & Scott, *A Greek-English Lexicon*, 81.
[23] Partington, *History of Chemistry*, 1: 37.
[24] David Furley, *The Greek Cosmologists*, vol. 1 (Cambridge: Cambridge University Press, 1987), 115.
[25] Ibid., 116.
[26] Philip Wheelwright, ed., *The Presocratics* (London: Macmillan, 1966), 177.
[27] Partington, *History of Chemistry*, 1: 39.

matter of philosophical dispute. 'The fact that Aristotle gives so much more detailed attention to Democritus than to Leucippus is doubtless explained partly by his closer temporal relation to the former and partly also by the greater degree to which Democritus had developed the implications of the doctrine'.[28]

Although their respective contributions to the production of the atomic theory cannot be securely determined, it is probable that the primary ideas came from Leucippus, and that Democritus, 'a more prolific but less original thinker, worked out the applications in greater detail'.[29] Hussey goes on to note that although there are some minor details on which the two philosophers are said to have diverged, nonetheless no difference as to the fundamental ideas on the atomic hypothesis has been proven between the two.[30]

'Some of the characteristics of the atoms as understood by Democritus are that they have weight, (or perhaps inertia) and that they 'differ in size … perhaps extensively',[31] though he considered spherical atoms to be the smallest. Partington considers that if Democritus is responsible for the argument in Aristotle's *De Generatione et Corruptione* [I, 2, 317[a]] then he, and not Epicurus, differentiated between physical and mathematical divisibility, arguing that the former finds a limit in the atom itself, but that the latter can proceed to infinity.[32]

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[28] Wheelwright, *The Presocratics*, 181.
[29] Edward Hussey, *The Presocratics* (London: Duckworth, 1972), 142.
[30] Ibid., 142.
[31] Partington, *History of Chemistry*, 1: 42.
[32] Ibid., 41.

'In his book *On Democritus*, Aristotle gave a detailed account of his metaphysical system; extracts from the book are given by Simplicius'.[33] In stating that the atoms were infinite in size and number, Freeman notes that Democritus may have been misunderstood by some who took this to mean that some atoms were very large, and that it was sometimes understood that he and Epicurus were at variance on this issue. This perceived distinction between the two thinkers may be expressed as Democritus positing that some atoms might be as vast in size as a universe, but Epicurus holding that all atoms were imperceptibly small. It is more plausible that for Democritus 'infinitely in size' meant 'infinitely small', without dismissing the notion of huge atoms as a logical possibility. The justification for this interpretation is that Simplicius' summary is clear on the matter, and that the notion of the possible existence of very large atoms is late.[34] 'Even if Democritus said that there were an infinite number of sizes, that is, that no two atoms were the same size, they could still all be imperceptibly small'.[35]

Epicurus, (342/41 – 271/70 BCE) a native of Samos, adopted the atomic theory of Democritus, 'but modified and improved [it] in many important directions',[36] and 'elaborated [it] into a series of logical systems'.[37] 'He overhauled Democritus' atomism so radically that his system was soon considered an independent one'.[38]

[33] Kathleen Freeman, *The Pre-Socratic Philosophers* (Oxford: Basil Blackwell, 1946), 299.
[34] Ibid., 299-300.
[35] Ibid., 300.
[36] Partington, *History of Chemistry*, 1: 137.
[37] Ibid., 138.
[38] *Routledge Encyclopaedia of Philosophy*, 3: 350.

Epicurus' principle atomic teachings derive from Leucippus and Democritus, including the doctrine that only atoms and the void exist. For him there exists an infinite number of atoms in ceaseless motion, undergoing elastic collisions in an infinite void, enabling complex aggregates of the atoms to form, although the tangible properties of these aggregates are apparent rather than real. In addition, 'All such qualities as heat, colour, taste and so on are derived from, and reducible to, differences in the primary properties of atoms, such as shape and position'.[39] Epicurus' teaching on the atoms differed in certain respects from that of Democritus, probably as a response to the criticisms that Aristotle made against the original atomic theory. One such matter left ill-defined by those earlier atomists involved the nature of the atoms themselves. Although they surely believed in the physical indivisibility of atoms, in other words they cannot be split, it is unclear whether they believed them to be mathematically divisible, *i.e*. divisible in thought. This provided a means for Aristotle to object to the atomists in that he could argue that they failed to distinguish between physical and mathematical divisibility of the atoms. 'Epicurus' answer was to postulate two types of minima and to distinguish clearly between them: the atoms are physical minima, the unsplittable units of which physical objects are composed, but the atom itself has size and it contains, and is made up of, mathematically indivisible parts'.[40]

Atomic morphology and size were problems which may not have been given due consideration by the earlier atomists. It may be that just as they had assumed that the number of the atoms was infinite, so too were their shapes and sizes. However, this

[39] G.E.R. Lloyd, *Greek Science after Aristotle* (New York: W.W. Norton, 1973), 22.
[40] Ibid., 22.

introduces the problem of maximum size, some atoms may be very large – perhaps sufficiently large as to be visible – which was surely unacceptable. Epicurus was able to overcome this difficulty by arguing that atomic size and shape ‘are not infinitely various, only indefinitely so’.[41]

Epicurus elevated weight to the status of a primary quality of the atoms, unlike Leucippus and Democritus who posited that ‘the primary properties of atoms are shape, arrangement and position alone’,[42] and for whom weight was no more than a secondary quality which came into play only when sufficient atoms have agglomerated to constitute a world. The question of world-formation was explained differently by Epicurus than by Leucippus and Democritus. These latter thinkers argued that the atoms are moving perpetually in all three dimensions, and that world-formation occurs when random collisions of atoms lead to atomic aggregations, which in turn attract other atoms. Epicurus postulated that the atomic movements must be in a downwards direction before world-formation can occur. Unlike Aristotle, who held that heavier bodies fall faster than light ones, Epicurus held that in the void all atoms – heavy and light alike – fall at the same speed.

However, in this account no two atoms will ever meet, let alone collide, so world-formation is excluded, and this led Epicurus to introduce his controversial hypothesis of the atomic swerve. Sometimes a vertically-moving atom will deviate to the slightest extent, thereby allowing it either to collide with another atom to initiate world-formation

[41] Ibid., 23.
[42] Ibid., 23.

or to facilitate further aggregation of atoms in an existing world. 'Although the evidence is incomplete and in parts unclear, Epicurus apparently applied the doctrine of the swerve to his account of the soul, to rescue his moral philosophy from determinism'.[43]

Three philosophers of great relevance to Boyle: Aristotle, Paracelsus and van Helmont.

Aristotle (382-322 BCE) born in Stagira, along with his predecessors Socrates and Plato comprises to many the greatest trio of philosophers ever to have lived.[44] He was considered by the ancients as the greatest scientist, and was pre-eminent in the various fields of the natural sciences until the Scientific Revolution. Along with his teacher Plato he dominated philosophy until the late Middle Ages. '[H]is adoption of the four Empedoclean elements and of the Pythagorean concepts of the perfection of spheres and circles, and his cogent arguments for a spherical, finite universe and for a spherical earth located at the exact center of the universe, left an indelible impression upon the experts as well as upon lay scientific writers of antiquity'.[45] His cosmological system was largely unchallenged until Copernicus did so in 1543.[46]

Aristotle's shift to qualitative teachings stands in contrast to the earlier quantitative doctrines of the Atomists and Plato. All natural materials are, for him, composed of the

[43] Ibid., 23.
[44] Georgios Anagnostopoulos, ed., *A Companion to Aristotle* (Chichester: Wiley-Blackwell, 2009), 3.
[45] William H. Stahl, *Roman Science* (Madison: University of Wisconsin Press, 1962), 26-27.
[46] Aristarchos of Samos (*c*. 310 – 230 BCE) is credited with being the first to postulate the heliocentric hypothesis, *i.e*. that the earth is not the centre of the cosmos, but that it revolves around the sun. See: Graham Shipley, John Vanderspoel, David Mattingly and Lin Foxhall, eds., *The Cambridge Dictionary of Classical Civilization,* repr. (Cambridge: Cambridge University Press, 2008), 75.

four elements first posited by Empedocles: earth, air, fire and water,[47] and these four elements were envisaged as the most rudimentary form of material substance. On the traditional view each element was produced from the prime matter, as 'it is receptive of the elemental contraries, hot, cold, wet, dry',[48] in accordance with the following scheme:

Earth is dry and cold

Water is cold and moist

Air is moist and hot

Fire is hot and dry.[49]

Each element has a natural movement and a natural place: earth tends to move downwards towards the ground, water naturally flows on the earth, air surrounds the earth itself, while fire seeks its place between the upper air and the orbit of the lowest celestial body: the Moon. The celestial bodies themselves consist of a fifth element, *aither*.

'The elements (earth, *etc*.) are the first level of actual ontological existence (there being no such thing as the Hot in separation), although even then the actual physical stuff we call earth is itself a compound of elemental Earth and Water'.[50] Indeed, all matter is composed of the four terrestrial elements combined in differing quantities, with all physical objects consisting of a hylomorphic combination of matter and its complement, form - their shape, structure or organising principle.

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[47] G.E.R. Lloyd, *Early Greek Science*, 107.
[48] Frank A. Lewis, 'Form and Matter', in Georgios Anagnostopoulos, ed., *A Companion to Aristotle* (Chichester: Wiley-Blackwell, 2009), 179.
[49] E.J. Dijksterhuis, *The Mechanization of the World Picture*, trans. C. Dikshoorn, paperback ed. (Oxford: Oxford University Press, 1969), 22.
[50] R.J. Hankinson, 'Science', in Jonathan Barnes, ed. *The Cambridge Companion to Aristotle* (Cambridge: Cambridge University Press, 1995), 151.

Partington states that Aristotle employed a supposed proof of the impossibility of a vacuum as an argument against atomism. Any position occupied by a body requires two spaces – the one filled by the body itself and empty space – but this is absurd. Empty space would be directionless in so far as it would lack the 'up and down' in which the natural movement of the elements takes place, and all bodies, whether heavy or light, would fall with equal speed through empty space, which is impossible.[51] He goes on to note that Aristotle has 'arguments based on ideas of infinity, limits, the infinite, divisibility of lines, *etc*., sometimes confusing mathematical and physical divisibility'.[52] He explains that 'particles of organic materials such as bone must have an upper and lower limit of size, outside which they cease to exist'.[53]

Paracelsus (1493-1541). 'Phillipus Aureolis Theophrastus Bombastus von Hohenheim, who later claimed the title Paracelsus (*i.e*. greater than Celsus, the Roman medical writer)'[54] was born in Einsiedeln, near Zürich. In early life he encountered mining technology and metals' study, and spent some time as an apprentice in the mines near Schwaz.[55] He may have studied medicine at the University of Ferrara (1513-16) though there is no documentary evidence of his receiving a degree. Paracelsus did work as an army surgeon (1517-24), then considered a lowly form of medical practice, as at that

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[51] Partington, *History of Chemistry*, 1: 78.
[52] Ibid., 78.
[53] Ibid., 78.
[54] Richard G. Olson, *Science and Religion, 1450-1900 From Copernicus to Darwin* (Baltimore: The Johns Hopkins University Press, 2006), 47.
[55] *Routledge Encyclopaedia of Philosophy*, 7: 205.

time surgeons were equated with barbers.[56] His restless, polemical nature meant that he travelled widely and wrote, or dictated, copiously.

'Paracelsus is best known as a vociferous critic of traditional medicine – his writings, frequently imitated in style by later followers, are filled with vitriolic and sarcastic condemnations of physicians, apothecaries, and the entire medical establishment'.[57] Webster argues that 'The degree to which Paracelsus stirred up the passions of his opponents is a measure of his success in sabotaging efforts aimed at permanently establishing the authority of Galen in the field of medicine. Thus the first major confrontation of the Scientific Revolution was between Paracelsus and Galen, rather than between Copernicus and Ptolemy'.[58] 'Medical alchemy (also known as *iatrochemistry* or *chemiatria*) would expand enormously in the sixteenth century due to the writings (and rantings)'[59] of Paracelsus. Osler asserts that 'His followers created a chemical philosophy that rivalled the mechanical philosophy in the seventeenth century, influencing the fields of chemistry and medicine as profoundly as Copernicus and Vesalius influenced developments in astronomy and anatomy, respectively.[60]

'Paracelsus' real achievement was his unified approach to chemistry which brought together alchemical, metallurgical and pharmaceutical techniques. Indeed he came to see the whole world and its creation in terms of chemical transformation and

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[56] Ibid., 205-206.
[57] Lawrence M. Principe, *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2013), 127.
[58] Charles Webster, *From Paracelsus to Newton: Magic and the making of Modern Science* (Cambridge: Cambridge University Press, 1982), 3-4.
[59] Principe, *The Secrets of Alchemy*, 81.
[60] Margaret Osler, *Reconfiguring the World* (Baltimore: The Johns Hopkins University Press, 2010), 118.

separation'.[61] His natural philosophy included a new doctrine of the elements. Instead of the traditional four Empedoclean elements of earth, air, fire and water, he advocated the *tria prima* of sulphur, mercury and salt. This system was an extension of the older sulphur-mercury dyad, going back at least to early Islamic alchemy.

'As in the earlier sulphur-mercury theory, the Paracelsian principles are not to be considered as the visible materials we see and call by these names. Rather, they are spiritual substances whose properties are resembled most closely in nature by sulphur, mercury and salt. Sulphur is the cause of combustibility, structure and substance. Solidity and colour are due to salt, while the vaporous quality is due to mercury. These three components, the combustible, the vaporous and the solid, may be demonstrated by burning a twig. Here one finds vaporous fumes (mercury), flame (sulphur), and ashes (salt)'.[62]

Van Helmont (1579/80-1644). Johannes/Jan/Joan/Jean van Helmont was born in Vilvoorde, Belgium, and graduated as an M.D. in 1599. He became 'an author of great influence whose restatement of the Chemical Philosophy was to become the basis of the iatrochemical school of the seventeenth century'.[63] He 'took Paracelsian chemistry to the next level, although deeply influenced by Paracelsus, did not follow him blindly and freely criticised many of Paracelsus' ideas. He did, however, emphasise the importance of chymistry (remember that the distinction between alchemy and chemistry did not

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[61] *Routledge Encyclopaedia*, 7: 207.
[62] Allen G. Debus, *The English Paracelsians* (New York: Franklin Watts, 1966), 27-28.
[63] Allen G. Debus, 'The Chemical Debates of the Seventeenth Century: The Reaction to Robert Fludd and Jean Baptiste van Helmont', in M.L. Righini Bonelli and William R. Shea, eds. *Reason, Experiment and Mysticism in the Scientific Revolution* (New York: Science History Publications, 1975), 35.

exist at this time) and its close link with medicine. Van Helmont developed his own philosophy of nature. His work surpassed that of his predecessors in the development of both theory and experimental methods'.[64]

'Van Helmont's comprehensive and influential worldview unifies chymical, medical, and theological ideas. He rejected the elemental status of the Paracelsian *tria prima* in favour of monism, arguing (like the ancient Thales) that water is the basic material substratum of all substances. He based this theory on the prominence of water in Genesis I and on laboratory experiments'.[65] The most famous of these is his growing a tree, fed only with water, over a five-year period. The great increase in weight for the tree caused van Helmont to conclude that the extra woody matter was produced from transmuted water.

Newman and Principe note that a significant feature of van Helmont's experimental approach was his adoption of a quantitative method, and his assertion that both weight and matter are always conserved.[66] 'As Van Helmont puts it, "Nothing comes into being from nothing. Hence weight comes from another body weighing just as much". What Van Helmont has in mind is what we would call in modern terms "mass balance", that is, the mass that goes into a reaction must also come out at the other end, regardless

[64] Margaret Osler, *Reconfiguring the World*, 124.
[65] Lawrence M. Principe, *The Secrets of Alchemy*, 134.
[66] William R. Newman and Lawrence M. Principe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2002), 68-69.

of any transformations that have taken place. This was not a conception that a strict follower of Aristotle could have maintained.'[67]

'Van Helmont recognised one general and 'astral-cosmic' force which he made responsible for all motion and change in the universe, which he called *blas*. In the first place there is *blas motivum*, a directed and determined motion, as when the wind blows or changes. This represents the *blas alternativum*, or *blas* of change. There is also a cosmic *blas* which is a kind of gravitational force governing stellar movement and meteorological change'.[68] He believed that 'the Aristotelians have overlooked the real internal principles that direct both animate and inanimate things – namely the hidden and self-moved *semina* and the *archeus* (which he calls the "internal efficient cause" of the body).'[69] 'The *semina* and the *archeus* lurk deep within the recesses of physical bodies and are responsible for their specificity, their transmutations, and their development. Unlike bodies at the macro level the *semina* operate by means of a "radical activity" that need not involve physical, bodily contact; hence, the principle that the mover and the moved must be in mutual contact does not apply to *semina*.'[70]

Van Helmont rejected both the four Empedoclean/Aristotelian elements and the three Paracelsian principles, asserting that the true elements are air and water, which are not interconvertible. He 'proceeds to show that the other two so-called elements, fire and earth, do not deserve the title, since fire is not a form of matter at all, and earth can be

[67] Ibid., 69.
[68] Walter Pagel, *Joan Baptista van Helmont: Reformer of Science and Medicine,* paperback ed. (Cambridge: Cambridge University Press, 2002), 87.
[69] Newman and Principe, *Alchemy Tried in the Fire*, 61-62.
[70] Ibid., 62.

formed from water, as he thought he proved by experiment.'[71] He claims to have been the 'inventor' of gas 'and distinguished gases from condensable vapours, from air, and from one another',[72] and derived the term 'gas' from the Greek 'chaos'.[73] He named some gases, including *gas sylvestre* (carbon dioxide)[74] and *gas carbonum* (carbon dioxide or carbon monoxide).[75]

[71] Partington, *History of Chemistry*, 2: 223.
[72] Ibid., 228.
[73] Ibid., 227.
[74] Ibid., 223.
[75] Ibid., 229.

BIBLIOGRAPHY

BIBLIOGRAPHY

Primary Sources:

Birch, Thomas, ed. *The Works of the Honourable Robert Boyle*. Vol. 1. London: A. Millar, 1744.

Boyle, Robert. *The Sceptical Chymist.* London, 1661. Repr. Kila, MT: Kessinger Publishing Co., 1991.

___. *The Sceptical Chymist.* London: 1661. Repr. London: Dawsons, 1965.

___. *The Sceptical Chymist.* Rev. ed. London: Dent, 1911.

___. *The Sceptical Chymist.* Rev. ed. London: Dent, 1967.

___. *The Sceptical Chymist.* Rev. ed. Mineola, NY: Dover Publications, 2003.

___. *The Sceptical Chymist,* 2nd ed. Oxford, 1680. Repr. New York: Gryphon Editions, 1997.

Hunter, Michael, ed. *Robert Boyle by Himself and his Friends*. London: William Pickering, 1994.

Hunter, Michael, Antonio Clericuzio and Lawrence M. Principe, eds. *The Correspondence of Robert Boyle*. 6 vols. London: Pickering and Chatto, 2001.

Hunter, Michael, and Edward B. Davis, eds. *The Works of Robert Boyle.* 14 vols. London: Pickering and Chatto, 1999-2000.

MacIntosh, J.J., ed. *The Excellencies of Robert Boyle.* Peterborough: Broadview Press, 2008.

Stewart, M.A., ed. *Selected Philosophical Papers of Robert Boyle*. Cambridge: Hackett, 1991.

Other Sources:

Anagnostopoulos, Georgios, ed. *A Companion to Aristotle*. Chichester: Wiley-Blackwell, 2009.

Anstey, Peter. *The Philosophy of Robert Boyle.* London: Routledge, 2000.

Barnes, Jonathan, ed. *The Complete Works of Aristotle.* Vol. 1. Princeton: Princeton University Press, 1984.

Bishop, A.C., A.R. Woolley, and W.R. Hamilton. *Minerals, Rocks & Fossils.* London: George Philip, 1999.

Blackburn, Simon. *Dictionary of Philosophy.* Oxford: Oxford University Press, 1994.

BIBLIOGRAPHY

Boas, Marie. *Robert Boyle and Seventeenth-Century Chemistry.* Cambridge: Cambridge University Press, 1958.

___. "An Early Version of Boyle's: Sceptical Chymist." *Isis* 45, no. 2 (July 1954): 153-168.

Brock, William H. *The Norton History of Chemistry.* New York: W.W. Norton, 1993.

Chávez-Arvizo, Enrique, ed. *Descartes Key Philosophical Writings*. Translated by Haldene, E.S., and G.R.T. Ross. Ware, Herts: Wordsworth Editions, 1997.

Chalmers, Alan. *The Scientist's Atom and the Philosopher's Stone*. Dordrecht: Springer, 2011.

Collins English Dictionary. Glasgow: HarperCollins, 2005.

Craig, Edward, gen.ed. *Routledge Encyclopaedia of Philosophy.* 10 vols. London: Routledge, 1998.

Crosland, Maurice P. *Historical Studies in the Language of Chemistry*. Repr. New York: Dover Publications, 1978.

Daintith, John, ed. *Dictionary of Chemistry.* 6th ed. Oxford: Oxford University Press, 2008.

___. *Dictionary of Physics.* 3rd ed. Oxford: Oxford University Press, 2009.

Debus, Allen G. *The English Paracelsians*. New York: Franklin Watts, 1966.

___. "The Chemical Debates of the Seventeenth Century: The Reaction to Robert Fludd and Jean Baptiste van Helmont." In *Reason, Experiment, and Mysticism in the Scientific Revolution,* edited by M.L. Righini Bonelli, and William R. Shea,19-48. New York: Science History Publications, 1975.

Davis, Tenney L. "The First Edition of the Sceptical Chymist." *Isis* 8, no. 1 (Feb. 1926): 71-76.

Dijksterhuis, E.J. *The Mechanization of the World Picture.* Translated by C. Dikshoorn, paperback ed. Oxford: Clarendon Press, 1969.

Dobbs, Betty Jo Teeter. *The Foundations of Newton's Alchemy*. Cambridge: Cambridge University Press, 1975.

Duddy, Thomas. '"A Piece of Green-Wood Burning," Boyle against the elements.' In *A History of Irish Thought*, 64-68. London: Routledge, 2002.

Emsley, John. *Nature's Building Blocks*. New ed. Oxford: Oxford University Press, 2011.

Encyclopaedia Britannica, Micropaedia. Vol.7. Chicago: Benton, 1976.

Ferguson, John. *Bibliotheca Chemica.* 2 vols. Repr. Kessinger Publishing Co., 2002.

Frank, Robert G. *Harvey and the Oxford Physiologists*. Berkeley: University of California Press, 1980.

Freeman, Kathleen. *The Pre-Socratic Philosophers*. Oxford: Basil Blackwell, 1946.

Furley, David. *The Greek Cosmologists.* Vol.1. Cambridge: Cambridge University Press, 1987.

Golinski, Jan V. 'Robert Boyle: scepticism and authority in seventeenth-century chemical discourse.' In *The Figural and the Literal – Problems of Language in the History of Science and Philosophy, 1630-1800*, edited by Andrew E. Benjamin, G.N. Cantor, and J.R.R. Christie, 58-82. Manchester: Manchester University Press, 1987.

Greenwood, N.N., and A. Earnshaw. *Chemistry of the Elements.* New York: Pergamon Press, 1984.

Haefner, Mark. *The Dictionary of Alchemy.* London: The Aquarian Press, 1991.

Hall, A. Rupert. *From Galileo to Newton.* Rev. ed. New York: Dover Publications, 1981.

Hankinson, R. J. "Science." In *The Cambridge Companion to Aristotle,* edited by Jonathan Barnes, 140-167. Cambridge: Cambridge University Press, 1995.

Healy, John F. *Pliny the Elder on Science and Technology.* Oxford: Oxford University Press, 1999.

Heather, Peter, and David Moncur, trans. *Politics, Philosophy, and Empire in the Fourth Century. Select Orations of Themistius*. Liverpool: Liverpool University Press, 2001.

Heilbron, J.L., ed. *The Oxford Companion to the History of Modern Science*. Oxford: Oxford University Press, 2003.

Hirai, Hiro, and Hideyuki Yoshimoto. "Anatomizing the Sceptical Chemist: Robert Boyle and the Secret of his Early Sources on the Growth of Metals." *Early Science and Medicine* 10, no.4 (2005): 453-477.

Holmyard, E.J. *Alchemy.* Repr. Mineola, NY: Dover Publications, 1990.

Honderich, Ted, ed. *The Oxford Companion to Philosophy.* Oxford: Oxford University Press, 1995.

Hornblower, Simon, and Anthony Spawforth, eds. *The Oxford Classical Dictionary.* 4th ed. Oxford: Oxford University Press, 2012.

Hume, David, *An Enquiry Concerning Human Understanding,* edited by Eric Steinberg. Cambridge: Hackett, 1993.

Hunter, Michael. *Boyle between God and Science*. New Haven: Yale University Press, 2009.

___, ed. *Robert Boyle Reconsidered*. Repr. Cambridge: Cambridge University Press, 2003.

Hussey, Edward. *The Presocratics*. London: Duckworth, 1972.

Latham, R.E. *Dictionary of Medieval Latin from British Sources.* London: Oxford University Press, 1975.

Leicester, Henry M. *The Historical Background of Chemistry.* New York: Dover Publications, 1956.

Lewis and Short. *A Latin Dictionary.* Repr. Oxford: Clarendon Press, 1988.

Liddell, H.G., and Robert Scott. *An Intermediate Greek-English Lexicon.* Rev. ed. Oxford: Clarendon Press, 1996.

___. *A Greek-English Lexicon*. Rev. ed. Oxford: Clarendon Press, 1996.

Loonan, Conleth P. "Robert Boyle on the Elements." M. Litt. diss., NUI Maynooth, 2010.

___.'Some Aspects of Robert Boyle's Corpuscular Hypothesis.' *Maynooth Philosophical Papers* 7 (2013): 46-58.

Lüthy, C., J.E. Murdoch, and W.R. Newman, eds. *Late Medieval and Early Modern Corpuscular Matter Theories.* Leiden: Brill, 2001.

MacIntosh, J.J. 'Boyle and Locke on Observation, Testimony, Demonstration and Experience.' *Croation Journal of Philosophy* 14 (2005): 275-288.

___. 'Robert Boyle's Epistemology: The Interaction Between Scientific and Religious Knowledge.' *International Studies in the Philosophy of Science* 6, no. 2 (1992): 91-121.

___. 'Robert Boyle on Epicurean Atheism and Atomism.' In *Atoms, Pneuma and Tranquility: Epicurean and Stoic Themes in European Thought.* Edited by Margaret J. Osler, 197-219. Cambridge: Cambridge University Press, 1991.

___. 'Perception and Imagination in Descartes, Boyle and Hooke.' *Canadian Journal of Philosophy* 13, no. 3 (1983): 327-352.

McMullin, Ernan, ed. *The Concept of Matter in Greek and Medieval Philosophy*. Notre Dame: University of Notre Dame Press, 1963.

Maddison, R.E.W. *The Life of the Honourable Robert Boyle*. London: Taylor & Francis, 1969.

Maia Neto, José R., and Elena C. Pereira Maia. 'Boyle's Carneades.' *Ambix* 49, no. 2 (2002): 97-111.

BIBLIOGRAPHY

More, Louis Trenchard. *The Life and Works of the Honourable Robert Boyle*. New York: Oxford University Press, 1944.

Morwood, James, ed. *The Pocket Oxford Latin Dictionary.* Rev. ed. Oxford: Oxford University Press, 2005.

Morwood, James, and John Taylor, eds. *The Pocket Oxford Classical Greek Dictionary*. Oxford: Oxford University Press, 2002.

Multhauf, Robert P. *The Origins of Chemistry*. London: Oldbourne, 1966.

Newman, William R. *Atoms and Alchemy.* Chicago: University of Chicago, 2006.

___. *Promethean Ambitions.* Chicago: University of Chicago, 2005.

___. 'The Alchemical Sources of Robert Boyle's Corpuscular Theory.' *Annals of Science* 53 (1996): 567-585.

Newman, William R., and Lawrence M. Principe. *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chemistry*. Chicago: University of Chicago Press, 2002.

Olson, Richard G. *Science and Religion, 1450-1900 From Copernicus to Darwin*. Baltimore: The Johns Hopkins University Press, 2006.

Osler, Margaret J. *Reconfiguring the World. Nature, God, and Human Understanding from the Middle Ages to Early Modern Europe.* Baltimore: The Johns Hopkins University Press, 2010.

___. 'Whose Ends? Teleology in Early Modern Natural Philosophy.' *Osiris* 16. *Science in Theistic Contexts: The Cognitive Dimensions* (2001), 151-168.

Pagel, Walter. *Joan Baptista van Helmont: Reformer of Science and Medicine*. Paperback ed. Cambridge: Cambridge University Press, 2002.

Patrides, C.A., ed. *The Cambridge Platonists*. Cambridge: Cambridge University Press, 1980.

Partington, James R. *A History of Chemistry*, vol. 1. London: Macmillan, 1970.

___. *A History of Chemistry,* vol. 2. Repr. London: Macmillan, 1969.

___. *A History of Chemistry*, vol. 3. London: Macmillan, 1962.

___. *A Short History of Chemistry.* Repr. New York: Dover Publications, 1989.

___. *A Text-book of Inorganic Chemistry*. 5th ed. London: Macmillan, 1947.

___. *General and Inorganic Chemistry.* 3rd ed. London: Macmillan, 1958.

Penella, Robert J. 'The Rhetoric of Praise in the Private Orations of Themistius.' In *Greek Biography and Panegyric in Late Antiquity,* edited by Thomas Hägg, and Philip Rousseau,194-208. Berkeley: University of California Press, 2000.

Picardi, L. and W. Bruce Masse, eds. *Myth and Geology*. London: The Geological Society, 2007.

Principe, Lawrence M. *The Aspiring Adept: Robert Boyle and his Alchemical Quest*. Princeton: Princeton University Press, 2000.

___.*The Secrets of Alchemy*. Chicago: University of Chicago Press, 2013.

___, ed. *Chymists and Chymistry*. Sagamore Beach: Watson Publishing International, 2007.

Sargent, Rose-Mary. *The Diffident Naturalist.* Chicago: University of Chicago Press, 1995.

Shapin, Steven and Simon Schaffer, *Leviathan and the Air-Pump*. Princeton: Princton University Press 1985.

Sharp, David W.A., ed. *The Penguin Dictionary of Chemistry.* 3rd ed. London: Penguin, 2003.

Shipley, Graham, John Vanderspoel, David Mattingly, and Lin Foxhall, eds. *The Cambridge Dictionary of Classical Civilization*. Repr. Cambridge: Cambridge University Press, 2008.

Simpson, D.P. *Cassells New Latin-English English-Latin Dictionary.* 5th ed. London: Cassell, *c*.1968.

Smith, William & John Lockwood. *Chambers Murray Latin-English Dictionary*. Repr. London: Chambers, 2010.

Sorabji, Richard. *Philoponus and the Rejection of Aristotelian Science*. Ithaca: Cornell University Press, 1987.

Stahl, William H. *Roman Science*. Madison: University of Wisconsin Press, 1962.

Stanley, Thomas. *History of Philosophy, The First Part*. London: Moseley and Dring, 1656.

The Holy Bible. Worcester, Mass: Isaiah Thomas, 1799. [The 'King James' version].

The Jerusalem Bible. London: Geoffrey Chapman, 1971.

Thomson, Thomas. *The History of Chemistry*. 2 vols. London: Colburn and Bentley, 1830.

___. *Outlines of Mineralogy, Geology, and Mineral Analysis*. Vol. 1. London: Baldwin & Cradock, 1836.

Thorndike, Lynn. *A History of Magic and Experimental Science.* Vols. 7 & 8. New York: Columbia University Press, 1958.

Thorsrud, Harald. *Ancient Scepticism*. Stocksfield: Acumen, 2009.

Von Rad, Gerhard. *Genesis a Commentary*. Translated by Marks, John, H. London: SCM Press, 1961.

Walker, Antoinette, and Michael Fitzgerald. *Unstoppable Brilliance*. Dublin: Liberties Press, 2006.

Webster, Charles. *From Paracelsus to Newton: Magic and the Making of Modern Science*. Cambridge: Cambridge University Press, 1982.

West, Muriel. 'Notes on the Importance of Alchemy to Modern Science in the Writings of Francis Bacon and Robert Boyle.'*Ambix* 9, no. 2 (June 1961):102-114.

Wheelwright, Philip, ed. *The Presocratics*. New York: Macmillan, 1966.

Wolf, A. *A History of Science, Technology and Philosophy in the 16th and 17th Centuries*. London: George Allen & Unwin, 1935.

Woody, Andrea I., Robin Findlay Hendry, and Paul Needham, eds. *Philosophy of Chemistry*. Oxford: Elsevier, 2012.

Online Sources:

Davidson John, S. *Annotations to Boyle's 'The Sceptical Chymist'*.

http://www.chem.gla.ac.uk/staff/alanc/annotations.pdf

Encyclopaedia Britannica online. http://www.britannica.com/

Oxford English Dictionary online. http://www.oed.com.jproxy.nuim.ie/

Stanford Encyclopaedia of Philosophy. http://www.plato.stanford.edu/