ELSEVIER

Stud. Hist. Phil. Sci. 35 (2004) 681–706

Studies in History and Philosophy of Science

www.elsevier.com/locate/shpsa

Interpreting Aristotle on mixture: problems about elemental composition from Philoponus to Cooper

Rega Wood [a], Michael Weisberg [b]

[a] *Department of Philosophy, Stanford University, Building 90, Stanford, CA 94305-2155, USA*

[b] *Department of Philosophy, University of Pennsylvania, 433 Logan Hall, Philadelphia, PA 19104-6304, USA*

Received 4 July 2003; accepted 24 February 2004

Abstract

Aristotle's *On generation and corruption* raises a vital question: how is mixture, or what we would now call chemical combination, possible? It also offers an outline of a solution to the problem and a set of criteria that a successful solution must meet. Understanding Aristotle's solution and developing a viable peripatetic theory of chemical combination has been a source of controversy over the last two millennia. We describe seven criteria a peripatetic theory of mixture must satisfy: uniformity, recoverability, potentiality, equilibrium, alteration, incompleteness, and the ability to distinguish mixture from generation, corruption, juxtaposition, augmentation, and alteration. After surveying the theories of Philoponus (d. 574), Avicenna (d. 1037), Averroes (d. 1198), and John M. Cooper (fl. circa 2000), we argue for the merits of Richard Rufus of Cornwall's theory. Rufus (fl. 1231–1256) was a little known scholastic philosopher who became a Franciscan theologian in 1238, after teaching Aristotelian natural philosophy as a secular master in Paris. Lecturing on Aristotle's *De generatione et corruptione*, around the year 1235, he offered his students a solution to the problem of mixture that we believe satisfies Aristotle's seven criteria.

Keywords: Mixture; Mixt; Chemical combination; Accidental potential; Potential; Elements; Medieval chemistry; Peripatetic chemistry; Aristotelian science; Richardus Rufus; Averroes (Ibn Rushd); Avicenna (Ibn Sina); Philoponus (Ioannes Grammaticus); John M. Cooper

E-mail addresses: rega.wood@stanford.edu (R. Wood); weisberg@phil.upenn.edu (M. Weisberg).

0039-3681/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.shpsa.2004.02.002

1. Aristotle's statement of the theory

Aristotle's account of mixtures is a theory of elemental composition which plays an essential role in his description of the natural world. Bodies are made up of heterogeneous parts which are composed of homoeomerous or homogeneous mixtures which are themselves comprised of the four elements: earth, water, air, and fire. The heterogeneous parts of the human body—for example, its head, limbs, and torso—are composed of homogeneous parts, such as bile, blood, bone, hair, flesh, lard, marrow, sinew, and so on (*History of animals* 1.1.487a2–10; 3.2.511b1–10; *Parts of animals* 1.2.640b18–29; 2.2.647b10–30; *Generation of animals* 2.6.743a1–36). The theory of the mixture explains how the combination of the elements can produce a homoeomery like flesh.

Though elemental bodies are combinable, Aristotle believes that mixture usually involves more complex bodies, themselves comprised of elements. Whether elemental or compound, according to Aristotle, the kind of bodies which are designed to be mixed are malleable and easily divisible—preeminently liquids, but also some solids. The process of mixing combines mixable bodies—henceforth, ingredients. The resulting mixtures are comprised of elements, but contrary to modern usage Aristotle considers such products like-parted. To avoid suggesting mixtures comprised of different kinds of parts, we will refer to *mixts*, not mixtures—a practice adopted by Paul Needham, following Pierre Duhem, to distinguish the products of mixture from the process that produced them (Needham, 2002, p. 687).

Aristotle presents his theory of mixture as the solution to a trilemma which suggests that mixture is impossible. Horn A establishes that if the elements continue to exist unchanged, they have not been mixed. Horns B and C show that if one or more of the elements does not continue to exist, then the elements cannot have been combined, and therefore mixture has not occurred (*GC* 1.10.327b1–6).

Aristotle claims this puzzle requires us to distinguish mixture from augmentation and from generation and corruption. He even requires us to distinguish mixture from alteration, since only separable bodies not properties can be mixed (*GC* 1.10.327b1–23). He solves the problem by claiming that in mixture the ingredients act to change each other so that they cease actually to exist, but they continue to exist potentially, and they can be separated out again (*GC* 1.10.327b23–30). Since ingredients are not destroyed in the course of mixture (*GC* 1.10.327b30), but continue to exist, the substratum of change is not prime matter. What is realized in a mixt is a potential of the ingredients, not a potential of matter (*GC* 2.7.334b20–21).

For Aristotle mixture is the unification of ingredients as a result of their mutually acting on each other and undergoing action (*GC* 1.10.328b20–24). The mutual interaction of the ingredients establishes an equilibrium between their powers (*GC* 1.10.328a28–30; 2.7.334b23); it also produces uniformity, so that every part of the mixt is the same as the whole (*GC* 1.10.328a11).

This description of mixture establishes seven criteria for a satisfactory account of Aristotelian mixture which are generally but not invariably accepted.[1] They are:

1. Uniformity: mixts are homogeneous homoeomeries; every part is the same as the whole; every part of blood must be blood (*GC* 1.10.328a9–11).
2. Recoverability: what is mixed must have the potential to reemerge from the mixt (*GC* 1.10.327b23–30).
3. Potentiality: ingredients exist potentially in the mixt (*GC* 1.10.327b23–30).
4. Equilibrium: the powers of the mixable bodies balance each other (*GC* 1.10.328a28–30).
5. Alteration: mixture involves the alteration of the qualities of the ingredients over time (*GC* 1.10.328a31–35, 2.7.334b10–27). Since their interaction is reciprocal, ingredients must share the same kind of matter (*GC* 1.10.328a20).
6. Incompleteness: the change involved in mixture is not total or complete. Not a potential of matter but of the ingredients is actualized in mixture (*GC* 2.7.334b20–21).

Moreover, the combination of these characteristics must (7) distinguish mixture from augmentation, alteration, and most importantly generation and corruption (*GC* 1.10.327b1–23).

Note that the Aristotelian problem of the mixture is not one which has been completely eliminated by scientific progress. Take the case of the composition of water from the elements hydrogen and oxygen. Modern chemistry has told us how hydrogen and oxygen act on each other to produce water and why the combination of two hydrogen and one oxygen atoms is stable. However, many questions related to the Aristotelian puzzle remain. If we know that water is made up of molecules, is it correct to say that all parts of water are water? Once oxygen and hydrogen are combined, is it possible to recover numerically the same atoms that existed prior to combination, given that the atoms share electrons in the molecule? Do atoms continue to exist when combined into molecules? Do distinct molecules continue to exist when they act together to form a substance, which has properties as a whole that no single molecule possesses? Just as the questions have changed, so have the constraints on replies and the methods of investigation. No doubt chemical investigation will shed most light on these questions, but philosophical

[1] Kit Fine presents eleven numbered criteria (1995), pp. 274–279. Absent from his list are our (4) equilibrium, (6) incompleteness, and possibly (7) difference from generation and corruption. Some of the disagreement about the criteria is merely terminological—for example, Fine's non-destruction turns out to be equivalent to our potentiality, which also includes Fine's containment. Similarly our uniformity criterion may include Fine's compresence. Concerning unity see our discussion of Richard Rufus. What Fine calls latent potentiality (ingredients have potentials not derived from mixture) seems to us a correct interpretation of Aristotle but not an important constraint in the discussion which concerns us here. By contrast we doubt that Aristotle is committed to Fine's derivability (a mixt can be derived from its ingredients) or proportionality (the form of a mixt is a ratio of its ingredients). At least about proportionality Fine himself has doubts, since his undetermination criterion conflicts with it.

considerations will also play a role. In this respect, strategies for solving these problems may bear a family resemblance to, and be open to some of the same criticisms as, the accounts we will describe here.

2. Outline: Rufus and the peripatetic tradition

The prospects for working out satisfactory answers to the modern questions are not good, judging from past experience. Working out a satisfactory interpretation of Aristotle's theory of the mixture occupied Aristotelians for thousands of years without resulting in consensus. This paper will consider attempts by four well known peripatetic philosophers: Philoponus (d. 574), Ibn Sina or Avicenna (d. 1037), Ibn Rushd or Averroes (d. 1198), and John M. Cooper (fl. circa 2000).[2] It will compare views from the sixth,[3] the eleventh, the twelfth, and the twentieth centuries and argue that in some respects the theory presented by a little known scholastic philosopher, Richard Rufus of Cornwall (fl. 1231–1256), in the thirteenth century achieves a more satisfactory solution. Contrary to Anneliese Maier (1952, pp. 3–140), who studied medieval theories of mixture more carefully than any other scholar and concluded that no medieval author could solve the problem, we will claim that Rufus presents a satisfactory solution to the question: what is the state of the ingredients in a mixt? Rufus explains how ingredients can survive in an altered form, constitute a mixt with properties different from their own, and ultimately reemerge in some circumstances.

Rufus presented his views in a question-commentary on Aristotle's *De generatione et corruptione*. Dated before 1238, this work records the earliest lectures on the topic offered in medieval Europe.[4] In 1238, Rufus became a Franciscan and began to study theology. Eventually he lectured on Peter Lombard's *Sentences* in Oxford and Paris, from about 1250. As a teacher of Aristotle, Rufus was strongly influenced by Averroes and somewhat hostile to Avicenna.

Knowing no Greek, Rufus was unaware of Philoponus's commentary on *De generatione et corruptione*, which was first translated into Latin by Hieronymus Bagolinus in the sixteenth century.[5] We begin our study with Philoponus because of the intrinsic interest of his interpretation and on account of his influence on the com-

[2] Apart from Cooper, other distinguished recent treatments of the subject include those by A. Code (1995), K. Fine (1995), R. Sharvy (1983), and R. Sorabji (1988), pp. 66–72.

[3] In the scope of a brief paper, we cannot consider the prior Stoic tradition. However, the reader may wish to consult Lewis (1988), Needham (2002), Todd (1976), and White (1986).

[4] Presently available only in manuscript, Erfurt, Quarto 312, this work has been edited for publication by Rega Wood and Neil Lewis. Concerning Rufus, see Wood (2003).

[5] Brief excerpts from Philoponus's commentary translated at the end of the twelfth century—such as, 'ut mel, ut huic dulce huic amarum'—appear as glosses in Oxford, Bodleian Library, Seldon supra 24. The same set of glosses includes philological remarks by Burgundio of Pisa and an anonymous twelfth century author. See Otte (1991). Apart from these snippets translated into Latin, even Greek readers were unlikely to find Philoponus's commentary. Only a single manuscript written before the fourteenth century has survived, according to its editor (Philoponus, *In Aristotelis De gen*, pp. vi–x).

mentary tradition today and in the Arabic world—particularly on Averroes, who sometimes cites Philoponus as Ioannes Grammaticus. Though there is no particular sign of Philoponus's influence on Averroes's treatment of this topic, the issues Philoponus raised were addressed by all subsequent commentators.

3. Philoponus (d. 574)

Philoponus's major contribution to the tradition was a novel interpretation of the third criterion, a new definition of potential.[6] According to Philoponus, the elements in an Aristotelian mixt survive in a limited, abated, diminished, or tempered state (*kekolasmenos*). As the introduction to a recent translation of Philoponus's commentary concedes, however, it is difficult to determine what he thinks is tempered or restrained. Is it the ingredients or their qualities (Berriman, 1999, p. 12)?

Philoponus explicates the potentiality involved in an Aristotelian mixt with a metaphor. It is not like the potential of an ignorant person to learn geometry, and neither is it like the potential of an accomplished geometer who is not actually using her knowledge (*DAn* 2.5.417a22–24). Rather the potential of the elements is like that of a drunken geometer who has the capacity to do geometry and tries to exercise it. Her geometrical knowledge is not 'unadulterated' (*eilikrinês*), as Philoponus (*In Aristotelis De gen* 188.22) might say. As a result of her impairment, her capacity is diminished. The claim is that when acted on by water, fire will not burn as effectively as it does by itself. It will not be as hot and dry as elemental fire, but will rather be colder and wetter than unmixed fire.

Here Philoponus may have drawn the inspiration for his interpretation of Aristotle from a passage in Book Two, Chapter Seven, of Aristotle's *De generatione et corruptione* (334b8–19) which reads, in the Joachim translation as modified by Barnes:

> Now since there are differences of degree in hot and cold, then although when either is actual without qualification, the other will exist potentially; yet, when neither exists in the full completeness of its being, but both by combining destroy one another's excesses so that there exist instead a hot which (for a hot) is cold and a cold which (for a cold) is hot; then there will exist neither their matter, nor either of the contraries in actuality without qualification, but rather an intermediate; and this intermediate, according as it is potentially more hot than cold or vice versa, will in accordance with that proportion be potentially twice as hot or as cold—or three times or whatever. Thus all the other bodies will result from the contraries, or from the elements, in so far as these have been combined; while the elements will result from the contraries, in so far as these exist potentially in a special sense—not as matter exists potentially, but in the sense explained above. (Aristotle, 1984, pp. 547–548)

[6] The authors are much indebted to D. S. Neil Van Leeuwen, who contributed substantially to this section of the paper.

As Frans de Haas reads him, Philoponus's drunken geometer 'is in actuality with respect to disposition' (De Haas, 1999, p. 31). The drunken geometer tries to exercise her geometrical knowledge, though her ability is impaired. Philoponus uses the drunken geometer to describe the abatement or adulteration which characterizes a kind of diminished actuality (ibid., p. 32).

The terminology here is potentially confusing, so we provide charts to explain where the terminology comes from and how our usage departs from current practice. The first chart shows how Franz de Haas uses the terminology. Philoponus himself contributes only references to 'first potentiality' and 'second potentiality' (*In Aristotelis De gen* 271.1–14). Derived from Aristotle's *De anima* (2.1.412a27–28) are 'first actuality' and 'second actuality'. De Haas describes the case of the drunken geometer as 'tempered second actuality' and Philoponus's special sense of potential (*GC* 2.7.18) as 'third potentiality':

> intoxication affects the disposition of the geometer and keeps him from reaching full second actuality . . . This example concerning *second* actuality ($188^{23–26}$) serves to introduce the notion of temperation which Philoponus then applies to the *first* actuality ($188^{23–26}$) by which the ingredients exist in a mixture. For in a later passage Philoponus locates the corresponding type of potentiality on a range *between first and second potentiality* ($271^{11–14}$). This location seems to rule out that the tempered second actuality of the drunk geometer, which is to be located between second potentiality and second actuality, is itself an illustration of the mode of being of the ingredients in a mixture. As the latter passage makes clear ($271^{11–14}$), their mode of being is conceived as a kind of *potentiality* between existence and non-existence, not between degrees of second *actuality*. (De Haas, 1999, p. 32)

Since 'tempered second actuality' is related to second actuality as 'third potentiality' is related to second potentiality, we think it is more perspicuous to use parallel terminology. We could have invented our own terminology (Chart 2). In the absence of a precedent, we would have preferred simply to describe four degrees of potentiality: remote potentiality (a suitable subject), incomplete disposition, disposition, and incompletely actualized disposition.

We chose instead to use the existing terminology, in part because it retains the traditional Aristotelian first and second actuality. This left us with a choice between referring to third potentiality and third actuality, or to tempered first actuality and tempered second actuality. Because it seems confusing for third degree potentiality to come between first and second potentiality, we decided to retain the phrase 'tempered second actuality'. However, the reader should not be misled by our usage here. Tempered second actuality is a form of potentiality. Any degree of actuality short of second actuality is also a kind of potentiality, and any degree of potentiality apart from first potentiality has some degree of actuality.

Charts 1–4 show De Haas's terminology (1), our terminology (2), and two possibilities for modifying De Haas's terminology (3 & 4). We have chosen the terminology in Chart 4, the second modification of De Haas's terminology we considered.

First Potentiality
Third Potentiality
Second Potentiality = First Actuality
Tempered Second Actuality
Second Actuality
Chart 1. Frans de Haas's terminology.

First Potentiality: Remote Potential
Second Potentiality: Incomplete Disposition
Third Potentiality: Disposition = First Actuality
Fourth Potentiality: Impaired Exercise
Second Actuality: Exercise = Second Actuality
Chart 2. Novel terminology for degrees of potentiality.

First Potentiality
Third Potentiality
Second Potentiality = First Actuality
Third Actuality
Second Actuality
Chart 3. Third degrees.

First Potentiality
Incomplete Second Potentiality
Second Potentiality = First Actuality
Tempered Second Actuality
Second Actuality
Chart 4. Wood & Weisberg's degrees of potentiality.

Incomplete second potentiality differs from first and second potentiality as tempered second actuality differs from first and second actuality. First actuality differs from second actuality as habitual knowledge differs from knowledge which is being exercised (*In Aristotelis De gen* 188.21–23). First actuality describes the state of someone sleeping who has geometrical knowledge.[7] Second actuality, a geometer doing geometry problems effectively; tempered second actuality, a drunken geometer trying to do geometry problems but failing, or at least not succeeding completely, on account of her impaired capacity (*In Aristotelis De gen* 188.23–26).

How to describe the related cases of first potentiality, second potentiality, and incomplete second potentiality is not as clear. But first potentiality is mere

[7] On the identity of first actuality with second potentiality, see De Haas (1999), p. 31: 'A human being who has acquired knowledge of a particular field (which is first actuality or disposition, *hexis*), e.g. a geometer or a grammarian, has *second* potentiality for knowledge'.

suitability for a capacity (for example, the state of someone who has not learned geometry, but could learn it), second potentiality is the same as first actuality, and tempered second potentiality is located between those extremes (*In Aristotelis De gen* 271.11–24). Tempered second potentiality, according to Philoponus, is more like the potential of an embryo to become a human person than like a mere sperm, more like the capacity of a partly educated child to learn geometry than like a newborn, and more like a house under construction than like a pile of bricks and stones (*In Aristotelis De gen* 271.14–24).

What is the case of the ingredients in a mixt? Are they like the drunk who has a disposition, but can only exercise it feebly? Or are they like an embryo in potential to become a human being? A case can be made for either interpretation. If De Haas is right to claim that the drunken geometer has the disposition though she cannot effectively exercise it, then it seems that ingredients too continue to possess their distinctive dispositions, but are prevented from their exercise. After all, Philoponus says of the ingredients and the drunk that each has limited activity and neither has the actuality it originally possessed:

> For in the blended wine there are both water and wine in potentiality, but not potentiality in the first sense, I mean in the sense of suitableness as water is in potential to mist; but neither simply in the second sense, I mean the one according to the state only, as it is with the sleeping geometer. But rather it is in the manner of the drunken geometer, trying to do geometry, acting according to his state (*hexis*) but not uncorruptedly (*eilikrinês*), that also the water and wine remain in the blend. For each acts (*energei*) in the mixt in a limited (*kekolasmenos*) way. So, on the one hand, both are preserved in potentiality, but neither is in actuality such as it was at the beginning. (*In Aristotelis De gen* 188.17–25)[8]

Distinctive in De Haas's interpretation is the claim that the drunken geometer is in a stated of limited actuality he calls tempered second actuality, rather than incomplete second potentiality. That is an attractive suggestion since Philoponus does say that each term in his simile between the impaired elements and the drunk is actual but abated (*kekolasmenos*). Also, it has Philoponus agreeing with Aristotle, according to whom drunks do not lose their dispositional knowledge or *hexis* anymore than sleepers (*Physics* 7.3.247b14–16). However, De Haas adopts the common opinion regarding elements; they are in incomplete second potentiality. Where most interpreters hold that the potential of the drunken geometer is the same as that of the ingredients (incomplete second potentiality), De Haas claims that only their abatement, not their position on the actuality/potentiality continuum, is similar. This interpretation seems somewhat uncharitable to Philoponus, since it means that it would be much harder for him to claim that the ingredients in a mixt are recoverable—their characteristic dispositions having been lost. So a good case can be made that Philoponus believed that Aristotle described the ingre-

[8] Thanks to Neil van Leeuwen for providing us with this translation.

dients in a mixt as being in tempered second actuality, or at least first actuality, rather than incomplete second potentiality.

A good case can also be made for the view that Aristotelian elements are in incomplete second potentiality in Philoponus's view. First, since he starts by describing two kinds of potential, it would be odd for him to continue with a kind of actuality. Of course, 'tempered second actuality' is not his phrase; he just describes another mode of potentiality, so this consideration has little weight. Much more importantly, in his exposition of Book 2, describing a complex body or *suntheton*, Philoponus clearly refers to what we describe as incomplete second potentiality. It is not entirely clear, however, that the passage in Book 2 refers to the ingredients in a mixt. Most straightforwardly it seems to refer to the disposition of the composite body being described, the *suntheton* itself, rather than its ingredients. And *suntheton* is a term that refers generally to complex bodies, more commonly to bodies whose ingredients are juxtaposed than to unified mixts (*Physics* 1.4.187b12–16; 8.9.265a21, *De caelo* 3.8.306b20, *GC* 2.7.334a27).[9]

Deciding between the two interpretations may not be possible. The texts being interpreted are brief and somewhat cryptic. Nonetheless, it is clear that Philoponus wants to draw our attention to the many different degrees of actuality/potentiality short of effective exercise of a disposition. He did not think that Aristotle's distinction between the potential for a disposition and for its exercise was adequate to a description of the states and changes in composite bodies. Referring very probably to *Physics* 8.4.255a30–b26,[10] Philoponus deliberately set out to refine the account (*In Aristotelis De gen* 271.14–24). And though we may not be able to decide whether he believed that ingredients were in a state of tempered second actuality or incomplete second potentiality, he certainly does not abandon the claim that the ingredients in a mixt are in a state of potentiality.

Philoponus urges us to consider actuality/potential as a continuum with considerable latitude, on the grounds that Aristotle's first and second act do not do justice to the phenomena. He is refining, not rejecting, Aristotle's account of potential. Hence Philoponus's interpretation of the potentiality criterion (3) does conform to the Aristotelian description of mixture.

What about the remaining criteria? If fire survives mixture in a diminished form, the process produces abatement not destruction, and hence it will be (7) different from corruption; also the change will be incomplete, as Philoponus states explicitly (6). Philoponus could suppose (2) that it is possible to recover unimpaired fire by separating it from water (and earth and air), though how persuasively this case could be made depends on whether he thought that ingredients were in incomplete second potentiality or tempered second actuality. If the ingredients are in first

[9] According to H. Joachim (1904), pp. 73–74, for Aristotle the term is reserved for mechanical mixture and distinguished from *mixis*. This seems a little narrow, however, and, of course, it does not tell us how Philoponus uses the term.

[10] The text indicates a reference to Book Seven, and Philoponus's editor, H. Vitelli, provides a reference to 7.3.245b9–11, but this seems unlikely. Another possibility is 7.3.247b1–18, but more probably the book number is misleading.

actuality or tempered second actuality, they retain their dispositions latently and their characteristic qualities in a diminished degree, so the case will be easier to make. Philoponus's account assumes (4) that fire and water are in equilibrium. There is nothing in his account that would prevent the mixt from being uniform, so that every part has the same characteristics and the same proportion of elements (1). Since there is a range of different potentialities, having different degrees of actuality, Philoponus's interpretation of Aristotle's theory explains very well why (5) the process of alteration is gradual and not instantaneous.

According to De Haas, Philoponus himself did not espouse the mixture theory he attributed to Aristotle. What is blunted in the process of mixture are the qualities of the ingredients in a mixt. Not the element fire, but its heat and dryness are blunted or diminished (De Haas, 1999, p. 33). What persists in a mixture is a tempered form of the elemental qualities; the elements themselves do not continue to exist in the mixt. As soon as the elements no longer have their essential characteristics in the highest degree, they cease to exist (ibid., pp. 34–37). So for Philoponus himself, unlike the Philoponean Aristotle, it is difficult or impossible to distinguish mixture from generation and corruption.

For Philoponus himself, at least as interpreted by De Haas (ibid., p. 35), no element can possess a quality essential to it except to a superlative extent. By contrast, for the Philoponean Aristotle, there is some latitude in the degree of heat that characterizes fire. If the heat of fire is curbed by the coldness of the contrary element, which balances its power to heat, there is considerable latitude. And that is what we should expect if we really want to maintain that fire itself, rather than qualities derived from fire, is an element of all mixts.

4. Avicenna (d. 1037)

Another influential interpretation of Aristotle based on latitude was offered by Avicenna almost five hundred years after Philoponus. Unlike Philoponus's account, Avicenna's views were generally known in the Middle Ages, though his *De generatione et corruptione* was not translated until the end of the thirteenth century.[11] For Avicenna the continued survival of the elements posed less of a problem than for authors who deny latitude, since a great range of qualities is compatible with the continued existence of any substantial form. Avicenna's views are summarized in the phrase 'fixed forms' (*formae fixae*), since he holds that each of the elements is fixed, firm, and permanent in its species, even in the presence of change in its distinctive primary qualities (Avicenna, *Liber tertius naturalium*, p. 63), though there are limits to such change (p. 139). What is fractured or broken in the process of mixture, for Avicenna, are not the elements but their primary qualities[12]—heat and dryness, for

[11] See S. van Riet's introduction to *Liber tertius naturalium: De generatione et corruptione* (Avicenna, 1987, ∗65).

[12] Here we use the phrase 'primary qualities' in the Aristotelian sense (*GC* 2.2.329b7–330a29) to refer to four qualities, hot, cold, dry, moist, as opposed to colors, tastes, textures, and so on. Primary qualities are reciprocally active or susceptible, rather than intangible and inert.

example. The alteration required in mixture affects the secondary perfections of the elements, not their primary perfections—in the case of fire, the qualities of heat and dryness, but not the nature of fire (pp. 64–65). The case of elemental change illustrates the limits of elemental latitude. According to Avicenna, when fire changes to air, the dryness of fire is so diminished as to be lower than the limits of its latitude. At that point, the substantial form of fire is immediately replaced by the form of air, infused not naturally but by the giver of forms, a celestial intelligence (*De philosophia prima*, pp. 488–490). In the case of mixture, too, the form of the mixt is introduced by the giver of forms. The qualities of the four elements dispose matter to receive the form of the mixt by acting on each other and mutually tempering each others' excesses.

According to Anneliese Maier, who looked at dozens of commentaries written over a period of centuries, historically the decisive objection against Avicenna has to do with (1) the uniformity criterion. If the mixt is to be uniform on this view (Maier, 1952, pp. 27–28), then any part of it, however small, will have five undiminished forms, the forms of four elements and the form of the mixt. Later Peripatetics considered that positing both the form of the mixt and an elemental form or forms was inconsistent with the uniformity criterion, since it would mean that each part was not of the same kind. It was tantamount to equating mixture with juxtaposition or, rather, apparent mixture without real uniformity. Even positing four distinct elemental forms in the mixt was unacceptable, according to Maier, because each elemental form directly and completely informs prime matter. Undiminished elemental forms can inform prime matter successively but not simultaneously, since each fully actualizes prime matter. There is also a problem about (3) potential, since for Avicenna, not the elemental forms themselves, but their primary qualities are broken, blunted, or corrected.

Avicenna's solution works well, however, for (2) recoverability, (4) equilibrium, (5) gradual alteration, and (6) incompleteness of change. Since the elemental forms remain, there is no difficulty in their reemergence; within the mixt their qualities act on each other to produce equilibrium. The change is accomplished by the infusion of the mixed form not in prime matter but in matter already disposed by the primary qualities of the elements. The primary qualities alter each other gradually. There is also no difficulty in distinguishing (7) mixture from generation and corruption, or from augmentation.

5. Averroes (d. 1198)

Conceived in opposition to Avicenna, whom Averroes characterized as confident but inexperienced,[13] Averroes's account of the mixture denies that there is any latitude in the primary qualities of the elements and affirms that the elemental forms themselves, not just their qualities, are broken, blunted, or diminished in the

[13] Averroes, as cited by A. Maier (1952), p. 29 n. 18: 'Paucitas vero exercitationis istius viri in naturalibus et bona confidentia in proprio ingenio induxit ipsum ad istos errores'.

process of mixing. For Averroes only the highest degree of heat and dryness is consistent with the continued existence of fire, so if fire as an ingredient is less than fully hot, its substantial form must be diminished. Hence his views were summarized in the phrase 'fractured forms' (*formae fractae*).

The difficulty with this position is that Aristotle holds that substantial forms cannot be diminished; they do not undergo remission (*Categories* 5.4a6–9; *Metaphysics* 8.3.1044a10–12). Averroes accepts this claim for most substantial forms, but he holds that elemental forms are different. They can be diminished, which is why they can be mixed together. His analogy is with colors: mixts are made from elements as all colors are comprised of different proportions of white and black.[14]

Averroes holds that elemental forms are intermediate forms, midway between substantial and accidental forms. Accidental forms like color can be more and less intense, but substantial forms cannot. One person is not more human than another; no dog more fully exemplifies canine nature than another. There is no room for degrees. Since elemental forms can shape independent substances like distilled water, they must be substantial forms, as Aristotelian science normally assumes. But since the theory of mixture requires that they be capable of diminution, they must have something in common with accidents, according to Averroes.

Against Averroes the objection could be made that it makes no sense to suppose that there are things which are diminished substances. Either a thing exists on its own, or it inheres in something else. But Averroes could reply that though the elements do sometimes exist as independent substances, they are more commonly found as ingredients in mixts. Since elements are so often found as ingredients in other things, it makes sense to suppose that their ontological status is different from substances which are not normally constituent parts. And, indeed, Averroes would have to claim that any body that serves as an ingredient is capable of diminution. For the distinctive properties of ingredients as separate bodies differ from those they display as ingredients in a mixture. As ingredients rather than independent substances, they will have diminished being.

According to Averroes, mixture results from the partial corruption of the elemental forms. The corruption is only partial, so that not prime matter but previously disposed matter receives the form of the mixt, which unites the diminished elemental forms. Since the elemental forms are diminished and the form of the mixt is not a wholly new, distinct, and additional form, Averroes did not encounter the criticism aimed at the multiplicity of forms posited by Avicenna.

How well does this account of mixture meet the seven criteria for Aristotelian mixture? Provision has clearly been made for (6) the incompleteness of the process of mixture and the sense in which the elemental forms are (3) in potential; also (7)

[14] Averroes, *In De caelo* 3.67: 'We say that the substantial forms of these elements are diminished in respect of perfect substantial forms; they are as it were an intermediate between forms and accidents. Therefore it is not impossible that their elemental substantial forms should be mixed in such a way that another form should arise from their commingling, as many intermediate colors are made from the mixture of white and black' (trans. R. Wood).

a clear distinction between mixture and generation and corruption has been made. Moreover, there is no reason to think that (1) uniformity or (4) equilibrium would be a problem. But there could be problems with (2) recoverability and (5) alteration. Alteration looks like the worst problem: since any departure from the highest grade of heat and dryness results in the immediate corruption of the elemental form according to Averroes, his account of mixture does not describe qualitative alteration followed by substantial change. Recoverability, too, would be a problem, since it is not clear that the diminished elemental forms united in the mixed form would maintain their identity.

6. John M. Cooper

Before considering the thirteenth-century author whose solution seems best to us, we should consider briefly one modern author. John Cooper was chosen for the clarity of his presentation and his detailed attention to the Aristotelian text (Cooper, forthcoming a).[15]

Oddly enough, in some respects his view resembles Avicenna's. Cooper, like Avicenna, distinguishes between the elements or simple bodies and their primary qualities. Though its primary qualities are modified in the mixt, fire itself 'remains in some underlying way possessed of its essential hotness' (ibid., p. 13). As Avicenna would put it, its primary perfection, the first principle which causes the heat, is unaffected; the forms are fixed not fractured. The elements themselves survive in the mixt, though their perceptible qualities change. Unlike Avicenna, however, Cooper holds that Aristotle's theory of simple bodies does not permit this interpretation. It seems to Cooper

> that Aristotle's own theory of what is essential to fire (and to the other simple bodies) blocks him from making good on his claim that each of the simple bodies survives in a mixture formed from them, because it remains in some underlying way possessed of its essential hotness or coldness, wetness or dryness. What Aristotle seems to need at this point is some way of characterizing the simple bodies' essential nature in non-qualitative (or non-perceptible-qualitative) terms: perhaps in terms of internal structure, or with some other way of identifying an indwelling nature . . . (Ibid.)

In other words, Cooper believes that Aristotle's theory of the mixture requires that there be considerable latitude in the primary qualities of the elements, but Cooper also believes that Aristotle's stated views permit no such latitude. Since elements are defined qualitatively, abatement implies destruction. The special form of potential proposed by Philoponus as characteristic of ingredients in a mixt is not consistent with the continued existence of elements. Accordingly, Cooper concludes that

[15] Also appears in Cooper (forthcoming b). Citations are to a pdf file kindly forwarded on 9 November 2003, though reference was originally to an earlier draft made available by the author on 12 June 2002.

elements in a mixture have been destroyed, and hence Aristotle cannot distinguish mixture from corruption (ibid., p. 14).

In place of Philoponus's special form of potentiality, Cooper suggests that Aristotle holds that ingredients survive in a mixt in so far as their powers, or rather modified versions of their powers, survive. In support of this suggestion, Cooper first argues that potentiality will not do by itself, since a remote potential for re-emergence—of fire, for example—would not distinguish mixture from the reciprocal generation and corruption of the elements. This argument would be more convincing if Cooper considered forms of potentiality other than first potentiality. Secondly, Cooper argues that the word usually translated as 'potential' should be translated 'power' instead and concludes that the retention of the elements' 'proprietary powers' in the mixt is what Aristotle had in mind. Cooper claims that Aristotle is using the singular *dunamis* at 327b30–31 in the same way he uses the plural *dunameis* (or rather the dative plural, *dunamesin*) at 328a29 (ibid., p. 4). The sentence at 327b reads 'The constituents, therefore, neither persist actually, as body and white persist; nor are they destroyed . . . for their potentiality (*dunamis*) is preserved'; the sentence at 328a reads 'there is a certain equilibrium between their powers' or as Cooper translates the passage: the elements in the mixt are 'pretty much equalized in their powers (*dunamesin*)'.[16] In the first case the term *dunamis* describes how the ingredients exist in the mixt, in the second what they can do, so it is hard to believe the term is being used in the same way.[17]

More importantly, for Cooper, as for Avicenna, what changes in the process of mixture are elemental qualities, not bodies. But if only qualities are altered in the process, mixture has not occurred, since simple bodies do not persist in a different state. If they themselves change, they are destroyed on this account, as we will see below. So this exposition of the potentiality criterion seems vulnerable to the criticism stated in horns A or C of the trilemma Aristotle set out to solve: if only their properties have been altered, the ingredients are not mixed; if they do not continue to exist, they cannot have been mixed. Cooper rejects Philoponus's interpretation of potential on the grounds that perceptible heat and dryness are essential properties of fire for Aristotle. From this it follows, according to Cooper, that something which has lost a 'great deal' of heat and dryness cannot be fire (ibid., p. 13). But if that is true, then a fire whose heat and dryness have been considerably abated has been destroyed. As in cases of generation and corruption, the fire does not survive the change. In support of his position, Cooper points out that flesh can be destroyed without acquiring opposite characteristics, if it loses its essential qualities. According to Aristotle, flesh does not survive death, though at least for a time a corpse resembles a living body in most respects. Cooper argues that by parity of reasoning, Aristotle must hold that a fire whose heat has been tempered has

[16] Oddly, Cooper employs this reading of *dunamis* only in the first of his two notes. The more traditional 'potential' replaces 'power' in the second note.

[17] R. Sorabji (1988), pp. 68–70, presents different reasons for rejecting the translation of *dunamis* as power at 327b30, without, however, committing himself, as Cooper points out.

thereby been destroyed and does not survive the process which produced its abatement.

It seems unlikely that Aristotle would accept Cooper's analogy between living flesh and hot fire. To begin with, analogies between elements or rather simple bodies and more complex bodies are of limited significance, since Aristotle's account of complex bodies differs from his account of simple bodies. Moreover, Cooper's claim about flesh is itself controversial.[18] Regarding fire, Aristotle is committed to the claim that not all fires have the same properties in the same degree. The properties of flame, fire par excellence, differ from those of ignited bodies such as a coal fire (*GC* 2.4.331b25, *Meteora* 2.8.366a3, *S&S* 437b20–23). R. Sorabji makes a similar point about degrees of heat in elemental air and fire (Sorabji, 1988, p. 71 n. 43).

Fire is a nature with powers and properties not constituted from heat and dryness. Heat or coldness is responsible for many qualities we would not associate with them, such as hardness/softness and tension/ductility (*Meteora* 4.12.390b2–10), but not lightness. Lightness is not a secondary, consequent property, but like heat and dryness, it is a characteristic, active principle of fire. Both in *De caelo* (3.5.302a15–b1, 7.305b10–15, 4.2–4, and especially 4.4.311a15) and in the *Topics* (5.5.134a26–135a8, 6.7.146a12–18), Aristotle describes fire's distinctive, active property not as heat but as lightness—its being rarified and fine.

As Cooper himself concedes, if fire and earth, air and water always had the same properties, Aristotle's chemical explanations will fail. Uniformly hot and dry fire would not be suited to be an element in all mixts; the fire in our fireplaces cannot be the same as fire as an element in flesh. Only one kind of fire, flame, possesses heat in a superlative degree. So the loss of a lot of heat need not mean the destruction of fire.

This is more obvious in the case of the other elements. Not all earth, for example, is cold in substantially the same degree. Its coldness can be substantially abated without it ceasing to be earth, and its heaviness is sometimes described as its distinctive active quality.[19] Hence it appears that for Aristotle more degrees of heat or coldness are compatible with an element's continued existence than Cooper supposes. But if this is so, then it was premature to reject Philoponus's exposition of the potentiality criterion.

In his second note on mixture, Cooper turns his attention to the process of mixture, in which ingredients act on each other after dividing each other. For Cooper, the division halts at small bits. Ingredients act by producing modifications in their primary qualities, such that each bit of every ingredient has the same degree of

[18] See Cohen (1984), pp. 189–194, who suggests that Aristotle's claim that flesh ceases to exist when life is lost may not be his considered position, since it is inconsistent with other statements. Cohen argues that Aristotle is equally committed to the view that death is not the destruction of flesh, but the destruction of a plant or animal and its organs. Dead men are reduced to flesh and bones; their person and their hands cease to exist but not their bones (*Met*. 7.10.1035a21–35).

[19] For lightness and heaviness as the distinctive qualities of air and water, see *Physics* 8.4.255b9–10 as well as *De caelo* 4.4–5.

heat or wetness as every other; their powers are equal. The mixt is uniform in that the primary qualities and the consequent secondary qualities are everywhere the same. But not all its ingredients will be present in every part of the mixt, however small. On the contrary, coherent bits of the ingredients are proximate to each other; what was fire is next to what was air and so on (Cooper, forthcoming a, pp. 22–24).

At first glance, this looks like a description of juxtaposition, a possibility Aristotle rejects at 327b31–328a17. But according to Cooper, it is precisely this passage which supports his interpretation. Aristotle argues that juxtaposition is not a possibility, since any part of the mixt, however small, can be further divided. It is possible to combine cereals in such a way that each grain is next to a different grain. But since the grains can be further divided, the internal parts of the grain will be next to parts of the same grain, not another grain. So perfect juxtaposition of different substances is not compatible with infinite divisibility, which is a quality characteristic of substances according to Aristotle.

> [Aristotle] now points out (328a15–16) that in fact [complete juxtaposition] is in any case strictly impossible, since (as he has argued elsewhere) matter is indefinitely divisible: the smallest bit, however small, of an ingredient stuff is divisible into further parts, and such parts of an undivided bit, when in the mixture, are adjacent to (alongside) not any parts of another ingredient but ones of the same ingredient of which they too are parts. You will in principle never reach a point in the analysis of an ingredient into its parts where all its parts ever could be aligned in the proposed way with the parts of another ingredient. Some parts will still remain inside undivided bits and so alongside their congeners, not alongside bits of another ingredient. (Ibid., pp. 21–22)

According to Cooper, in a mixt 'small bits [of the ingredients] act on one another, each causing the other to shift in its perceptual characteristic of hotness–coldness and wetness–dryness so that they reach a new, common position on those scales'. But this interaction requires that the ingredients survive 'as small coherent masses' (ibid., p. 22).[20] Cooper argues as follows:

> [N]otice that the objection . . . clearly carries over also to stuffs formed from ingredients that in the new substance do not retain their full natures, but only, as on Aristotle's theory, some diminished or 'restrained' version of those. In that case, too, it cannot be that in the mixture all the bits of the materials coming from any one of the ingredients are aligned alongside bits coming from the others. Because of indefinite divisibility and like-partedness, there will always be parts of the new substance that came, not from a different source-ingredient from that of their immediate neighbors, but from the same ingredient. (Ibid., p. 21)

[20] Dealing with the problem of how ingredients interact without being juxtaposed, Paul Bogaard has suggested that in homoeomeries, existing at a low level of complexity, 'the individuation of parts does not obtain or is minimized' (Bogaard, 1979, p. 29).

He concludes:

> [Aristotle's] theory involves the inclusion in the mixture of bits of the ingredients, just as was the case on the rejected alternatives discussed in 327b32–328a17. The important difference is that on his theory, but not on the alternative, the bits do not remain possessed in full actuality of the defining perceptual qualities of the ingredients from which they came . . . (Ibid., p. 24)

Cooper might argue that his account is not tantamount to juxtaposition, since the ingredients interact. As a result of their interaction there is a shift in their tangible characteristics, a change in hotness and dryness which interpenetrates all parts. But this might also be true of ordinary cases of juxtaposition. Suppose hot, dry paper balls were combined with cold, damp paper blocks. We would expect the resulting aggregate 'to reach a new, common position' on the scales of hotness–coldness and wetness–dryness. But we would not describe this aggregate as a unified Aristotelian mixt no matter how small the blocks and balls are. Still, perhaps this objection is ill considered, since for Aristotle heat and dryness are definitive, chemically active, and seemingly constitutive properties.

Suppose then that Cooper's mixt will not be combined only 'relative to perception' (*GC* 1.10.328a15). Nonetheless, his account of mixture faces difficulties with (1) the uniformity criterion; it is not the case that however small the parts of a mixt are, they will have the same proportion of the same ingredients. Cooper points to the distinction between sameness of perceptual qualities and sameness of ingredients. He claims that Aristotle insisted on the former and that he either did not or should not have argued for the 'interfusion' of the ingredients of the mixt—that is, the claim that every part of the mixt, however small we choose, will have the same ingredients (Cooper, forthcoming a, p. 24). But this claim seems contradicted in the very passage on which Cooper bases his interpretation: see particularly 328a9: 'the part exhibit[s] the same ratio between its constituents as the whole'.

As we noted, according to Anneliese Maier, the decisive scholastic objection to Avicenna was that each part of an elemental mixt, however small, would have to have five forms, the forms of the elements and the form of the mixt. But since Cooper holds that 'small volumes of its'—that is, a mixt's—'mass would not' have all four elements (ibid., p. 30), his view is not vulnerable to that criticism. Bits of matter that originated as fire would be juxtaposed with bits of matter that originated as water, but there would be only a single actual form, the mixt form. Apparently, then, the elements survive in the sense that material which originated in elements persists and is informed by the new mixt form. Also, the primary qualities of the mixt are a result of the interaction of its ingredients. Recovery (2) of the ingredients would require the reappearance of their corrupted forms. So this is different from juxtaposition of bodies whose form survives, but not different from (7) generation and corruption. The same criticism can be made of Cooper's interpretation of (3) the potentiality criterion; it implies destruction of the original ingredients.

What about the other criteria? A strength of the view is its account of (6) incompleteness; (5) gradual alteration is also a phenomenon that should present no problem. The achievement of (4) dynamic equilibrium is a feature of mixture, but not necessarily the mixt.[21]

7. Richard Rufus of Cornwall (d. 1259?)

Characteristically, Rufus starts by locating the difficulty precisely.[22] The problem is that Aristotle's theory of mixture requires that substantial forms be less than fully actual, that they be diminished or tempered, but Aristotle also denies that substantial forms can be diminished (*Categories* 5.4a6–9; *Metaphysics* 8.3.1044a10–12). Rufus sets out to solve that problem by presenting a form of Averroes's solution (fractured forms), but, unlike Averroes, Rufus denies that elemental forms are in any sense accidents.

Rufus's is a modal version of Averroes's claim that elemental forms are themselves broken or diminished. He holds that elemental forms differ in their degree of actuality; in a mixt they have less than full actuality. The degree to which an elemental form is actual provides for latitude or gradual change. Since elemental forms can be more or less actual, they admit of degrees like accidents, while remaining potential substantial forms. Though she did not know Rufus's works, Anneliese Maier recorded his influence (Maier, 1952, pp. 46–86); she describes various forms of the modal interpretation of Averroes from Bacon (d. 1292) to Baconthorpe (d. 1346), with a high point in the works of Francis de Marchia (d. 1344).

Rufus objects to Averroes's claim that elemental forms are quasi-accidental on metaphysical grounds. Elements and mixts belong to the genus of substance. But

> [nothing] can be an accident in itself and substance in regard to something else, it must be a substance in itself before it can be a substance in regard to something else, and therefore [nothing] can be an accident in itself and produce substance. For a thing is not a substance because it produces a substance, but rather: because a thing is a substance, it produces substance. (Q290.23ra)

[21] In his first note Cooper holds that the elements work 'dynamically against one another in such a way as to sustain [flesh]' (forthcoming a, p. 7). This claim may not be made in the second note, though there is reference to a 'common equilibrium state' on p. 22.

[22] That is, after considering how fire enters mixts, Rufus raises the following doubt, *In DGen* 1.6.5: 'De forma miscibilium dubitatur—scilicet, quomodo miscibilia sunt in mixto, quia forma substantialis non recipit intensionem vel remissionem, et tunc vel penitus sunt formae miscibilium in mixto (et tunc quattuor corpora actu) vel penitus non sunt (et tunc sola materia)' (Erfurt Quarto 312, fol. 16vb). Henceforth Q312.16vb.

Accidents depend on substances and not vice versa. Accidents can cause changes in substances, but they cannot produce or comprise substances.[23]

This is Rufus's reply to those who hold that the substantial forms of elements are accidents. But today, as in Rufus's day, there are many who hold, as Rufus puts it, that heat is the substantial form of fire. That is because, as Cooper points out, Aristotle speaks of the primary qualities as the differentiae of the elements (*GC* 2.3.330b6) and as constituting elements (*GC* 2.3.329b14). But though Aristotle says that fire is an excess of heat (*GC* 2.3.330b26), he does not say that heat is the form of fire. Rather he seems to think that strictly speaking fire is the form of the simple body we identify as fire, saying that 'the simple body corresponding to [what we call] fire is fire-like, not fire' (330b21–24). At *Metaphysics* 10.1.1052b5–15, Aristotle distinguishes elemental fire from fire as 'a particular thing with a nature of its own'. Earth is referred to as a form (*Plants* 2.2.824a29). Air is said to be more form-like than earth (*GC* 1.3.318b27–32).

Of course, if W. Charlton is correct to claim that elements are not hylomorphic composites but rather the most fundamental matter—that is, matter directly informed by accidents—then Rufus's theory will fail, and a theory more like Cooper's will succeed (Charlton, 1970, esp. pp. 73–75, 132–136). H. Robinson has argued against this claim, however, and A. Code has also rejected Charlton's account of substantial change.[24] So it would be premature to reject Rufus's theory on these grounds.

Another potential problem is that Aristotle describes both simple bodies and contraries as elements, sometimes reserving the term 'element' for simple bodies (*GC* 1.7.334b17) and sometimes speaking as if more properly the elemental contraries themselves—hot, cold, moist, and dry—were elements (*GC* 2.3.330a33). More generally, it is a problem for Aristotelian science. For Aristotle states both that the real elements are contraries (*GC* 2.3.329b14, *Parts of animals* 2.646a13–24) and more often that they are simple bodies (*GC* 1.10.327b13–22, *Metaphysics* 5.8.1017b10 & 10.1.1052b5–15). Nor does he seem to be speaking loosely when he says: 'An element . . . is a *body* into which other bodies must be analysed . . . not itself divisible into bodies different in form' (*De caelo* 3.3.302a15–19, emphasis added).

This disagreement has led authors such as Averroes to hold that elements are quasi-accidental and Cooper to claim that 'the natures or essences [of simple bodies must] be specified in . . . qualitative terms' (Cooper, forthcoming a, n. 11).

[23] Rufus, *Dissertatio in Metaphysicam* 8.1: 'Sed modo videtur quod calor sit forma substantialis ipsius ignis. Inseparabile enim est ab igne et ipso corrupto corrumpitur ignis, et plures dicunt quod formae substantiales elementorum sunt qualitates accidentales eorum, utpote calor forma substantialis ignis.

Ad hoc dicendum quod non sunt formae substantiales elementorum. Impossibile enim est ut aliquid sit in se accidens et in respectu alterius substantia. Oportet enim ut prius sit substantia in se quam in respectu alterius, et ideo non potest aliquid esse accidens in se et facere substantiam. Non enim est substantia, quia facit substantiam; sed quia est substantia, ideo facit substantiam' (Q290.23ra). See also Rufus, *In DGen* 1.6.5, Q312.16vb, his refutation of Averroes's view or at least the view Rufus identifies as Averroes's; cf. Rufus, *Memoriale in Metaphysicam* 7.16, Q290.49va.

[24] See Robinson (1974), Code (1976), and Cohen (1984).

Contrary to these claims, Rufus could point to Aristotle's claim in the *Physics* (1.6.189a29) that contraries do not 'constitute the substance of anything'. Where Cooper points to the fact that Aristotle holds that differentiae of fire are hot and dry, Rufus could point out that not just elemental differentiae but all differentiae are qualitative, and none of them are constitutive (*Topics* 4.2.122b15–17). Substances are not comprised of non-substances (*Physics* 1.6.189a29); every part of a substance is a substance (*Categories* 5.3a30–33, *An. Pr.* 1.32.147a27).

Cooper would also criticize Rufus's understanding of the potential existence of elements in a mixt. According to Cooper:

> Commentators have long noticed . . . that this can be neither of the two connected cases of potentiality that Aristotle famously distinguishes in *De Anima* 2.5.417a22–24. It is neither a case of the sort of potentiality a young untaught person has for geometrizing (namely, he has the potential for this that all humans have got by their nature of rational beings—they can learn geometry and then use it), nor that which an accomplished geometer, when he is not using his knowledge, has for geometrizing. (Cooper, forthcoming a, p. 8)

Contrary to Cooper, however, it appears that for Rufus, the potential of the elements in the mixt is like the potential an accomplished but sleeping geometer has for doing geometry. In the case of fire subsisting as an element in a mixt, what keeps it from boiling the mixt is not sleep but the cold being exercised by the water (and to a lesser extent the earth) in the same mixt. In the absence of that restraint, the fire would emerge from potential and exercise its capacity to heat fully.

Following Averroes, Rufus distinguishes between essential and accidental potential, where essential potential covers a range of cases from bare possibility to more developed capacities, including the capacity for geometrizing found in a person whose general education has included instruction in measurement and arithmetic, for example. Something essential is missing in all such cases, however, and, according to Rufus, it must be added by an external agent. By contrast, where there is accidental potential, only an external obstacle prevents the actualization of the potential. Everything essential to the exercise of the power is present, but, as it were, accidentally obstructed.[25]

For Rufus, mixts are the result of a combination of elemental forms in accidental potential which yield to each other, collapsing together into the form of the mixt.[26]

[25] On Rufus's understanding of this distinction, see Rufus (2003, pp. 86–87). Also see Aristotle, *Metaphysics* 9.7.1048b37–1049a18.

[26] Rufus, *In DGen* 2.4.3–4: 'Sunt enim ibi [in mixtione] ut potentiae et non in suis actibus ultimis, et in hoc deficiunt a forma substantiali simpliciter; eo autem quod simul coniunctae possunt perficere materiam, plus habent quam accidentia.

Postea quaeritur qualiter cedant in unum, quia ea quae sunt de contrarietate passiva non habent contrarietatem ad ea quae sunt de contrarietate activa. Ergo non faciunt unum medium cum his.

Dicendum quod licet non cedant in unum cum his, tamen omnia cedunt in unam formam, quia illa quae sunt de contrarietate passiva disponunt materiam ad recipiendum, et ea quae sunt de contrarietate activa in materia sic disposita recipiuntur, ut eam compleant' (Q312.18ra).

According to Rufus, elemental forms in accidental potential have their primary qualities in some degree. Only actual fire is absolutely hot, but fire in accidental potential also produces heat; indeed, even some degrees of fire in essential potential cause weak heat.[27]

Since Rufus's account of the mixture involves a balancing act, you might think that his account would have difficulty with the uniformity criterion, but it does not. For Rufus, elemental forms are 'confused' in the nature or form of the mixt;[28] there is, as Cooper would put it, 'interfusion'. 'Confusion' for Rufus is a technical term, one which is difficult to translate; it does not refer to disarray, mental or otherwise. Rather, it literally means fusion together. That meaning persisted in English into the eighteenth century; the *OED* describes 'a mixture in which the distinction of the elements is lost by fusion, blending, or intimate intermingling'. The last instance of this usage quoted comes from 1782; it is found in the works of the chemist who discovered oxygen, Joseph Priestley. The important thing to note about this confusion or interpenetration is that all the forms involved are unextended, as is their union, which cannot be thought of in spatial terms. Consequently there is uniformity all the way down. However finely you divide the mixt, the same ingredients will be present in the same proportion as in the whole. Another strength of Rufus's account is the way he distinguishes mixture from generation and corruption: his account of the incompleteness of the process of mixture. In elemental change, a new actual element is produced from the bare potential for that element present in matter. By contrast, the elements already have a more developed potential for mixture when the process begins, and their potentials are not fully actualized in the mixt. According to Rufus, mixture is not strictly speaking motion at all, since it is not a change from [bare]

[27] Rufus, *In DGen* 1.6.5: 'Propterea, ut mihi videtur, possumus dicere sic: quod potentia materiae est natura quaedam incompleta quae, mota per agens extrinsecus plus et plus, ultimo fit necessitas et forma in actu. Et antequam est necessitas, semper est forma in potentia essentiali et indiget agente; et cum est necessitas, tunc est in potentia accidentali et per se ipsam exiens in actum si non sit prohibita. Et in tali statu, ut mihi videtur, debemus ponere formas miscibilium in mixto, ita ut cum quaelibet possit de se exire in actum, quaelibet tamen per aliam prohibetur. Sic ergo non est ibi actu forma, nec tamen sola materia, sed potentia mota ad formam—ad quam potentiam, quia ipsa est natura formalis, consequitur virtus. Et sic etiam ad talem potentiam motam ad formam ignis, cum ex terra generatur ignis, consequitur caliditas in eadem materia adhuc exsistente sub forma terrae.

Et sic possumus ibi duo videre—quod, scilicet, terra manens sub forma terrae alteratur de frigido in calidum—et etiam illud—scilicet, qualiter alteratio praecedit generationem, cum tamen accidens semper causetur aliquo modo a forma substantiali. Quia caliditas remissa in praedicto casu causatur ex potentia ad ignem parum mota; et intensior caliditas, ex eadem potentia magis mota; et intensa caliditas simpliciter, ex forma ignis simpliciter ente.

Ad ultimum autem debemus dicere quod forma elementi est in potentia non essentiali sed accidentali. Et ideo sine omni agente extra potest sibi solvere prohibens et exire in actum. Si enim esset in potentia essentiali et ob hoc diceretur mixtum, eadem ratione aliquod simplex diceretur mixtum, vel ipsa materia, eo quod sunt ibi omnes formae in potentia essentiali' (Q312.16vb–17ra). See also Rufus, *Memoriale in Metaphysicam* 7.16, Q290.29va; *Dissertatio in Metaphysicam* 9.4, Q290.27vb.

[28] Rufus, *Memoriale in Metaphysicam* 7.16: 'Dici potest quod miscibilia sunt in mixto actu incompleto et diminuto, et ita patet conclusio. Sed ut quaesita in parte ista pateant intellige quod miscibilia sunt in mixto non potentia essentiali nec in actu, sed in potentia accidentali sive secundum actum incompletum, non tamen violente, propter confusionem formarum suarum in naturam tertiam quae est forma mixti' (Q290.49va).

potential to actuality. Rufus describes mixture as a form of change intermediate between alteration and generation.[29]

In a gesture toward Averroes, Rufus describes elemental forms as intermediate between substantial and accidental forms, since in a mixt elemental forms are not fully actualized.[30] Most importantly, Rufus holds that mixts are not fully unified. Since the elemental forms are only fused together, not completely united in the composite form, they produce composite or confused unity in the mixt—the unity of interpenetration rather than the absolute unity of a single nature.[31] Mixts have more unity than the aggregates produced by juxtaposition, but they are not absolutely unified.[32] Another problem with unity results from the nature of the primary contraries. Strictly speaking for scholastics hot is not the contradictory opposite of cold. For scholastics, there is no single continuum from 10,000 Kelvin to absolute zero, coldness which is the result of the complete absence of heat. Rather there are two distinct qualities that interfere with each other. Since there is no intermediate point on a single continuum, there will be no completely unified temperature. Nonetheless, hot and cold act as virtual contradictories, in that the more cold acts on heat the cooler it gets. Hence the result of primary qualities acting on each other will produce an intermediate, almost complete unity. Thus, though he concedes the force of the objection, Rufus claims that a mixt is less like an aggregate than a unity.[33] Faced

[29] Rufus, *In DGen* 2.5.2: 'Dicendum quod ratio motus non salvatur in mixtione, nec est vere aliquis motus, quia forma mixti (quae dico est elementaris) non solum est in potentia in ipsis miscibilibus, nec formae miscibilium in mixto. Et propterea non est ibi vere exitus de potentia in actum nec motus secundum completam rationem motus. Sed tamen sicut ibi <*add.* est E> motus est medio modo se habens inter generationem et alterationem, sic <sicut E> formae miscibilium (prout in mixto sunt) medio modo se habent inter formas substantiales et accidentales, ut prius dictum est' (Q312.18rb).

[30] Rufus, *In DGen* 2.4.3: 'Possumus iterum dicere quod aliqua mixtio est sic, in qua unum contrarium est sic in necessitate, alterum autem non, ut est in aliquo mixto quando est in corruptione. Et iuxta hoc possumus verificare hoc quod dicit Commentator, quod formae elementorum sunt media inter substantias et accidentia sive formas substantiales et accidentia, ut intelligamus hoc secundum quod sunt in mixtione. Sunt enim ibi ut potentiae et non in suis actibus ultimis, et in hoc deficiunt a forma substantiali simpliciter; eo autem quod simul coniunctae possunt perficere materiam, plus habent quam accidentia' (Q312.18ra).

[31] Rufus, *In DGen* 2.5.2: 'Item, sicut forma mixti non est simpliciter una sed una composita vel confusa, sic motus mixtionis est unus confusus' (Q312.18rb).

[32] Rufus, *In DGen* 2.4.5: 'Sed sive sic sive non, videtur quod duo contraria non cedunt in unum nisi in unum aggregatum, quia potentia ad caliditatem non est frigiditas. . . . Possumus concedere quod non cedunt simpliciter in unum, sed tamen plus est ibi unitatis quam aggregatum' (Q312.18ra).

[33] Rufus, *In DGen* 2.4.5: 'Sed sive sic sive non, videtur quod duo contraria non cedunt in unum nisi in unum aggregatum, quia potentia ad caliditatem non est frigiditas. Sed cum illa potentia movetur ad caliditatem, solum recipit plus caliditatis, ergo haec potentia incomplete mota nihil habet frigiditatis. Et similiter potentia ad frigiditatem non est caliditas—frigiditas, dico, incomplete mota. Et sic quamvis illae duae potentiae incompletae sint in mixto sicut dictum est, tamen neutrum participat naturam alterius; non cedunt in unum nisi tantum in unum aggregatum.

Possumus concedere quod non cedunt simpliciter in unum, sed tamen plus est ibi unitatis quam aggregatum. Quia licet potentia ad calidum, eo quod mota est ad caliditatem, nihil habeat frigiditatis, tamen, eo quod frigidum attingit ipsum secundum virtutem, quantum invenit eam deficere a calido, tantum movet ipsam frigidum. Et sic sunt haec duo contraria aliquo modo unita in una potentia' (Q312.18ra). A related problem pertains to the relation of the active and passive contraries. Cf. Rufus, *In DGen* 2.4.4, Q312.18ra.

with the objection that the interfusion of forms in accidental potential would not be able to unify the substance or complete matter, Rufus offers two replies. First, he says that though separately they would not suffice, together they do.[34] Confronting the objection that adding potentials does not produce actuality, Rufus reconsiders and replies that the preservative power of place supplies any missing actuality.[35] This is a result with which Rufus was doubtless satisfied, since he wants to explain why mixts are stable, but more easily destroyed than elemental bodies. They are corruptible even in their natural place and without external forces acting on them.

In an attempt to preserve this result, Rufus confronts another objection: If all four qualities are present in just the right proportion to balance each other perfectly,[36] why does that not produce a perfectly stable mixt that is incorruptible? After considerable discussion Rufus concedes the possibility of such balance, but escapes the consequence with another appeal to the power of place. Mixts are found near the center of the universe, 'which is the place that is most unnatural for and contrary to fire. For this reason although fire is [initially] equal to its contrary, yet it is more quickly diminished by the contrariety of place than its contrary'. The claim is that an element which is not in its natural place is inherently unstable. Hence even a mixt which was initially perfectly balanced would be corruptible.[37]

[34] Rufus, *In DGen* 2.4.3, Q312.18ra, as quoted previously.

[35] Rufus, *In DGen* 2.4.6: 'Sed adhuc videtur quod si forma substantialis elementi secundum quod est in potentia non potest complere materiam, et coniunctio unius ad alteram nihil affert actualitatis, sed magis reducit ad potentiam, tunc omnia simul iuncta non possunt complere materiam, ergo oportet ponere ibi aliam formam.

Et possumus hoc concedere hoc modo, ut dicamus quod in quolibet elemento est sua materia et sua forma et praeter hoc natura loci, quae non est pars rei sed est salvans formam in materia. Et dicemus tunc quod <quid E> haec natura sicut in radice est una, sed per diversa loca et corpora diversificatur, et ex parte qua diversificata est radicatur et tenet se in diversis miscibilibus, et ex parte ea qua una est unitur illa natura quae est in uno miscibili illi quae est in alio, et sic continet mixtionem. Et quamvis formae miscibiles secundum se non possent complere materiam, possunt tamen per actualitatem quam recipiunt ex isto continente' (Q312.18ra–rb).

[36] Here (*In DGen* 2.5.3) and elsewhere Rufus calmly assumes that different proportions of the elements produce different mixts, but when actually faced with the question of how mixts made up of the same four elements in the same state of accidental potential can be different from each other, Rufus does not reply by appealing to differences in proportion. Instead, he offers two other possible explanations: perhaps not all the elements are in accidental potential. Or perhaps the elements are in accidental potential for different species of those elements. The fire in glass, for example, might be in accidental potential for light rather than flame. See Rufus, *In DGen* 2.4.3, Q312.18ra.

[37] Rufus, *In DGen* 2.5.3: 'Videtur etiam quod quamvis sit aequalitas, non semper permanebit eadem proportio. Et sic peccabit secunda ratio, quia locus compositorum est circa medium, et ille locus est maxime igni innaturalis et contrarius. Et propterea, licet ignis sit aequalis suo contrario, citius tamen diminuitur per contrarietatem loci quam suum contrarium.

Ponamus quod quantum suum contrarium mutatur contra ignem per naturam loci, in tantum sit ignis in aliquo mixto maioris potentiae quam suum contrarium secundum se, ita quod potentia ignis sit aequalis aggregato ex potentia sui contrarii et ex potentia loci. Et tunc videtur quod talis complexio stabit in eadem proportione.

Possumus dicere quod hoc non est verum, quia ex parte potentiae ignis nihil est quod non possit diminui; ex parte autem praedicti aggregati aliquid est quod non diminuitur cum agit—scilicet, potentia loci, quia haec est magis per naturam supraelementarem quam per naturam elementarem. Et ex hoc accidit igni diminutio, ita quod in fine habeat ignis corrumpi in quolibet mixto' (Q312.18rb–va).

Rufus's attempt to deal with auxiliary problems suggests that he is satisfied with his response to the principal challenge. Should he have been satisfied? His theory provides an account of (1) the uniformity of the mixt; every part has the same ingredients as well as the same characteristics. His ingredients are (2) recoverable as soon as they escape the influence of the other ingredients. Their potential (3) is one of the traditional states described by Aristotle, and their powers are (4) in balance. Mixture results from (5) alteration as the ingredients act on each other over time. The change involved is (6) incomplete, which makes the process of mixture (7) different from generation and corruption.

8. Conclusion

So it looks as if Rufus has provided an account of Aristotelian mixture that is more complete and less vulnerable to attack than the other accounts we have considered. Like that of the Philoponean Aristotle, its greatest weakness as an interpretation of Aristotle is the possibility that Aristotle did not believe that fire really was an element or would not admit that there was potential fire that was moderately hot. But these are not problems with saving the phenomena. Confronted with such objections, Rufus might also have ventured to correct the consistency of Aristotle's Aristotelianism. Probably Rufus considered fundamental the claims that elements are bodies, and that elemental bodies must have characteristics that vary as they interact. In a similar situation he revised the Aristotelian account of projectile motion to conform to a fundamental tenet of Aristotelian science: bodies as bodies cannot move themselves.[38]

Compared with other Aristotelians, Rufus is remarkably successful in presenting a consistent account that satisfies Aristotle's criteria for mixture. Unlike Avicenna and Cooper, Rufus has no difficulty with the uniformity or potentiality criteria. Neither does Rufus encounter the problems met by Averroes with the recoverability and alteration criteria. Contrary to Anneliese Maier, Rufus (and probably a number of other scholastics as well) can satisfactorily account for the potential existence of ingredients in a mixt. The major problem faced by Rufus's account of the composition of homoeomeries such as flesh from four elements—and the composition of more complex mixts from non-simple ingredients—can be stated as a question: does it make sense to talk about diminished degrees of actuality and enhanced degrees of potentiality with different characteristics? But even here modern accounts of the differences between potentials or capacities, such as those

[38] Rufus (2003), pp. 238–239, 8.3.1: 'In respondendo ad dubitationem quae est in proiectis (8.10.266b29–31) dixit ita—scilicet, quod medium sicut aer vel aqua (8.10.267a2–4) quia facile mobile est, cum sit humidum et non habens situm vel figuram terminatam, hoc modo cum movetur, consequenter ex se ipso potest movere sine eo quod tunc moveatur ab alio.

Et hoc videtur falsum, quia cum movet, ad minus movetur ex se, sed non ab alio. Sed sicut ostensum est superius nullum corpus inquantum corpus potest se movere. Ex quo apparet quod pars aeris mota non potest ulterius movere nisi cum moveatur ab extra'.

presented by Michael Smith (forthcoming), might make for a receptive audience. Rufus's account of mixture surely deserves further attention.

Acknowledgements

Thanks are due particularly to Neil Lewis and D. S. Neil Van Leeuwen. We are also indebted to Allen W. Wood, Michael Wigodsky, William Newman, Frans de Haas, and John Cooper, named here more or less in the order we consulted them. Though they read it too late to incorporate it into the article, the authors' thinking also benefited from the opportunity to consult Dorothea Frede's paper 'On mixture and mixables' (forthcoming), which takes a very different perspective on the problem of Aristotelian mixture.

References

Aristotle (1984). *The complete works of Aristotle, 2 vols*. (J. Barnes, Ed.). Princeton: Princeton University Press.

Averroes (1550). *Aristotelis opera cum Averrois Cordubiensis commentariis, 5. In De caelo*. Venice: Iuntina. (Translations in this paper by R. Wood)

Avicenna (1977). *De philosophia prima* (S. Van Riet, Ed.). Louvain: E. Peters.

Avicenna (1987). *Liber tertius naturalium: De generatione et corruptione* (S. van Riet, Ed.). Leiden: Brill.

Berriman, S. (1999). Introduction. In J. Philoponus, *On Aristotle, 'On coming-to-be and perishing 1.6–2.4'* (C. J. F. Williams, Trans.). Ithaca: Cornell University Press.

Bogaard, P. (1979). Heaps or wholes: Aristotle's explanation of compound bodies. *Isis*, *70*, 11–29.

Charlton, W. (1970). *Aristotle's 'Physics': Books I and II*. Oxford: Clarendon.

Code, A. (1976). The persistence of Aristotelian matter. *Philosophical Studies*, *29*, 357–367.

Code, A. (1995). Potentiality in Aristotle's science and metaphysics. *Pacific Philosophical Quarterly*, *76*, 405–418.

Cohen, S. (1984). Aristotle's doctrine of the material substrate. *Philosophical Review*, *93*, 171–194.

Cooper, J. (forthcoming a). Two notes on Aristotle on mixture. In J. Cooper, *Knowledge, nature, and the good*. Princeton: Princeton University Press.

Cooper, J. (forthcoming b). A note on Aristotle on mixture. In J. Mansfeld, & F. de Haas (Eds.), *Aristotle: On generation and corruption I*. Proceedings of Symposium Aristotelicum, XV (2001). Oxford: Oxford University Press.

De Haas, F. (1999). Mixture in Philoponus: An encounter with a third kind of potentiality. In J. Thijssen, & H. Braakhuis (Eds.), *The commentary tradition on Aristotle's 'De generatione et corruptione'* (pp. 9–46). Turnhout: Brepols.

Fine, K. (1995). The problem of mixture. *Pacific Philosophical Quarterly*, *76*, 266–369.

Frede, D. (forthcoming). On mixture and mixables. In J. Mansfeld, & F. de Haas (Eds.), *Aristotle: On generation and corruption I*. Proceedings of Symposium Aristotelicum, XV (2001). Oxford: Oxford University Press.

Joachim, H. (1904). Aristotle's conception of chemical combination. *The Journal of Philology*, *29*, 72–86.

Lewis, E. (1988). Diogenes Laertius and the Stoic theory of mixture. *Bulletin of the Institute of Classical Studies*, *35*, 84–90.

Maier, A. (1952). *An der Grenze von Scholastik und Naturwissenschaft* (2nd ed.). Rome: Edizioni di Storia e letteratura.

Needham, P. (2002). Duhem's theory of mixture in the light of the Stoic challenge to the Aristotelian conception. *Studies in History and Philosophy of Science*, *33*, 685–708.

Otte, J. (1991). An anonymous Oxford commentary on Aristotle's *De generatione et corruptione*. *Traditio*, *46*, 326–336.

Philoponus (1897). *In Aristotelis libros 'De generatione et corruptione'* (H. Vitelli, Ed.). Berlin: Reimer.

Robinson, H. (1974). Prime matter in Aristotle. *Phronesis*, *19*, 168–188.

Rufus (2003). *In Physicam Aristotelis* (R. Wood, Ed.). Oxford: Oxford University Press.

Rufus. *Dissertatio in Metaphysicam*. Citations are to the manuscript at Erfurt University, Amploniana Quarto 290.

Rufus. *In DGen*. Quotations are based on a provisional edition by N. Lewis and R. Wood. Since this edition is unpublished, citations are to the manuscript at Erfurt University, Amploniana Quarto 312.

Rufus. *Memoriale in Metaphysicam*. Quotations are based on a provisional edition by R. Wood and N. Lewis. Since this edition is unpublished, citations are to the manuscript at Erfurt University, Amploniana Quarto 290.

Sharvy, R. (1983). Aristotle on mixtures. *Journal of Philosophy*, *80*, 439–456.

Smith, M. (forthcoming). Rational capacities. In C. Tappolet, & S. Stroud (Eds.), *Weakness of will and varieties of practical irrationality*. Oxford: Oxford University Press.

Sorabji, R. (1988). *Matter, space, and motion*. Ithaca: Cornell University Press.

Todd, R. (1976). *Alexander of Aphrodisias on Stoic physics: A study of 'De mixtione' with preliminary essay, text, translation and commentary*. Leiden: Brill Academic Publishers.

White, M. (1986). Can unequal quantities of stuffs be totally blended? *History of Philosophy Quarterly*, *3*, 379–389.

Wood, R. (2003). Richard Rufus of Cornwall. In G. Gracia, & T. Noone (Eds.), *A companion to philosophy in the Middle Ages* (pp. 579–587). Oxford: Blackwell.