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Aristotle on Pure and Simple Stuff

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Aristotle's scientific works deserve our attention and reflection for their intrinsic merits and revealing limitations just as much as because they clarify other facets of the Aristotelian corpus and because they significantly shaped almost two thousand years of science and of fields bordering on science, such as alchemy.[1] For all these reasons, then, the Stagirite's view of the physical world deserves to be determined with as much precision as possible. This paper is meant to bring aspects of his worldview into sharper focus by attempting to reconsider and to clarify a crucial Aristotelian notion: the homoeomers. A view that has been entertained traditionally by commentators is that the four simple bodies in the sublunary world (earth, water, air, and fire) cannot exist independently according to Aristotle; a consequence of this view is the general belief that all homoeomers or uniform bodies have to be compounds.[2]

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[1] The volume edited by Viano (Viano 2002a) as well as Newman (2006)'s reconsideration of the place of alchemy in the context of the scientific revolution are substantial contributions to our understanding of the *Nachleben* of *Meteorology* IV, especially with respect to late ancient, medieval and early modern alchemy, and the dawn of chemistry. See also Düring (1944), 10–11.

[2] Olympiodorus (6th c. Platonist), in trying to mark out the thematic scope of *Meteor*. IV, notes that it is not sufficient to consider this book to be about *ta homoiomerē*; instead, we should more strictly define its central topic as the homoeomers resulting from the combination of the four so-called elements (272.5 ff.). A similar view was defended in modern times. In the first part of the 20th century, Joachim, for instance, notes in his commentary on *Generation and Corruption*: 'In Aristotle's system the *homoiomerē* are the first, or most rudimentary, compound natural bodies (…). Every *homoiomeres* is a chemical compound of the same four "simple" bodies (Earth, Air, Fire, Water) or – more precisely – of the same four "elementary qualities" (Hot, Cold, Dry, Moist). The four constituents enter into combination in a determinate quantitative proportion, which differs in the different *homoiomerē*; so that each *homoiomeres* is characterized by its distinctive "combining formula" (*logos tēs mixeōs*).'

I would like to suggest that, while Aristotle consistently maintains that the four basic opposites (hot, cold, moist, dry) cannot exist independently, this is not always the case with the four simple bodies.[3] My central claim is that *Meteorology* (from now on: *Meteor.*) IV – Aristotle's 'chemical treatise' – provides evidence that, contrary to the traditional interpretation of his natural philosophy, not all uniform stuffs (*ta homoiomerē*) are necessarily compounds of the four simple bodies or even of just earth and water; indeed, some of them consist of only one element: earth *or* water. This, however, does not prevent, for instance, bodies consisting entirely of earth from displaying

(1926), 64. Holmyard (1931), 17, in commenting on *GC* II.8, points out that 'All other substances [i.e. other than earth, water, air and fire] are composed of *all* the elements or "simple" bodies.' Düring (1944), 14 too seems to consider as indisputable that all homoeomerous bodies are compounds in Aristotle's view. Mugler writes in the introduction to his translation (Mugler 1966, xi) that, while the *phusika sōmata* are composed of the homoeomers, the latter are composed of the four elements. Coutant (1971), xiii notes unequivocally: 'All terrestrial bodies contain all four elements.' More recently, Bolzan (1976), 139 and Freudenthal (1995), 11 appear to have taken all the homoeomers to be combinations of the four elements and so do Viano (2006), 122, 124 and Lewis. Lewis (1996), 144, n. 244 reacts with surprise to the distinction between simple homoeomers and mixed ones mentioned by Alexander (in his commentary of *Meteor.* IV.10): 'This distinction is confusing. It seems that a simple body is one composed of water (and so moist), while mixed bodies are composed of water and earth, and so thickened by cold. Yet, of course, all things are actually composed of all four elements.' Alexander, I should add, seems willing to persuade himself that each homoeomer consists of a combination of all four simple bodies, despite the fact that occasionally, as here, he cannot help virtually quoting Aristotle who unambiguously and insistently marks a distinction between simple and compound homoeomers.

[3] I take earth, water, air and fire to be simple in the sense that they cannot be analyzed into simpler bodies (see, e.g., *De Caelo* III.3 302^{a}16) and implicitly I agree with Gill's view that, while the basic contraries are crucial to our understanding of elemental transformation (the persistent quality corresponds to matter in substantial transformation, while the quality being replaced and the replacement correspond to lack, *sterēsis*, and to form in a generic formula of change), they are not constitutive ingredients of the aforementioned bodies. As Gill (1989), 77 notes: 'This immunity from further division is the reason why Aristotle claims that the elements are generated from one another. The elements must come to be from one another because, unlike all other generated things, there is nothing simpler from which they can be produced.' For a detailed argument, see Gill (1989), especially ch. 2; for an alternative view on this subject, see, e.g., Lewis (1996), 15–22.

different behaviors among them and, so, from being divisible into distinct kinds or forms (*eidē*) according to their material dispositions.[4] *Meteor*. IV may not be a fully polished treatise and, as a consequence, it tends to be less consistent than one wishes it were; however, even if Aristotle was not fully committed to the idea that, in addition to compounds, there are also pure and simple stuffs – consisting of only one element – in the sublunary world, at the very least it is reasonably clear, as I hope to prove, that he did not completely reject this possibility. If my interpretation is correct, we may need to rethink and redefine Aristotle's concept of homoeomer, which involves uniformity, but not *necessarily* a composite nature (although, again, *most of* the homoeomers are indeed compounds). In short, I would like to reexamine both the notion that all uniform bodies are compounds (of earth and water or of all four simple bodies) and the cognate notion that elements cannot exist on their own, but are only present in potentiality as ingredients in chemical combinations. The last section of my paper will consider several implications of my reexamination for Aristotle's cosmology and theory of *mixis* and separation, as well as a few additional clarifications regarding the 'purity' of the simple bodies and the emergence of both dispositional and categorical properties.

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[4] For Aristotle's view of what we would call today dispositional properties, see especially his theoretical treatment of *dunamis* in *Metaphysics* Δ.12 and in Θ. Dispositions, I should add, are still very much at the heart of modern theories and debates in the philosophy of science, metaphysics and philosophy of mind. Recent studies on dispositions have offered divergent views on this notion; let me quote here two relatively uncontroversial definitions. The first one was proposed by Tim Crane (in Crane, 1996, 1–2) and seems to echo what Aristotle himself wrote about powers or capacities: '…A disposition is a property (such as solubility, fragility, elasticity) whose instantiation entails that the thing which has the property would change, or bring about some change, under certain conditions. For instance, to say that some object is soluble is to say that it would dissolve if put in water… The fragility (solubility, elasticity) is a disposition; the breaking (dissolving, stretching) is the *manifestation* of the disposition… These characteristics of the world – fragility, poisonousness, flammability, nourishingness, loyalty, honesty, courage and humour – are all dispositions.' And, in Goodman's (1955), 40 suggestive formulation, we are urged to notice that 'Besides the observable properties it exhibits and the actual processes it undergoes, a thing is full of threats and promises. The dispositions or capacities of a thing – its flexibility, its inflammability, its solubility – are no less important to us than its overt behaviour, but they strike us by comparison as rather ethereal.'

NOTE ON THE HOMOEOMERS AND ON THEIR PLACE IN *METEOR*. IV

Both the beginning and the end of *Meteor*. IV (chapters 1 and 12) stress the intermediary status of the homoeomers, between the simplest bodies (earth, water, air and fire) and the non-uniform bodies – *ta anomoiomerē*, such as complex organs or parts; a hand, for instance, is made of a number of homogeneous tissues, i.e. organic *homoiomerē* (see, e.g., *Meteor*. IV.10, 388[a]18–19).[5] This intermediary zone does not seem to have a very prominent position in Aristotle's metaphysics, yet it is at least indirectly pivotal to his metaphysics in so far as *almost* all substances are either uniform bodies or aggregates of uniform bodies; and, one should hurry to add, this intermediary domain is certainly crucial to his science and natural philosophy.

The transparent etymon of *homoiomeres* ('like-parted') is *homoion meros* ('like / similar part'). The term is generally applied to materials that are uniform or homogeneous: a portion of the pulp of, say, an apple displays the same basic characteristics as any other portion of the pulp of that apple. Each part of a homoeomerous body is 'synonymous' with the whole. Uniform stuffs, such as wood and stone, marrow and iron, salt and blood, appear to be the respective results of various processes of generation, which hinge partly on the thoroughly uniform combination of ingredients like the four so-called elements (earth, water, air, fire) or of the two types of exhalation (dry and moist *anathumiaseis*). Different ratios between such elemental constituents and the thermic processes affecting them account largely for the enormous variety among uniform bodies with respect to their appearance and behavior. As we learn especially from *GC* I.10, the original ingredients (*ta mikta*) of such uniform compounds survive in the final products *potentially*, some of their original properties being still present in the resulting homoeomer, although the process of *mixis* or *krasis* – the thoroughly uniform mixing – also generates new, emergent properties in the resulting compound (the *michthen*

[5] Another line of demarcation between homoeomers and anomoeomers is generally the complexity of their respective functions. Although the organic like-parted bodies can be defined in virtue of their functions (for example, flesh as a medium for touch, blood as a conveyor of food to the other parts of an organism etc.), in addition to their material composition (see, e.g., *GA* II.1 734[b]30–31 and much of its book V, and *PA* II), the anomoeomers (such as a hand) are generally capable of fulfilling more complex functions and activities (*erga* and *praxeis*). Implicitly, the simple or uniform parts are *for the sake of* the complex ones, of which they are constituent parts. See also *PA* II.1 646[b]12 and *Meteor*. IV.12.

or *krathen*). This is significantly different from earlier theories (of the pluralists among the Presocratics, and of Plato), where uniform materials are created by the rearrangement of elements, for instance, of minimal particles of some sort in Democritean atomism and in Plato's brand of atomism in the *Timaeus*.

According to the Aristotelian account, notably in *GC* I.10, we can divide a uniform body (e.g., a piece of bark or of fat) into ever smaller pieces without ever reaching or isolating the original constituents, since they are not *actually* present in the homoeomer,[6] in contrast with a mechanical mixture (of, say, ground pepper and salt or, to take Aristotle's example, wheat and barley) in which the particles would preserve their defining nature. Furthermore, the small bits into which the homoeomer has been divided will display the same defining material properties as any other portion of that body and indeed as that whole uniform body. This kind of similarity between part and whole (as well as between parts within a whole) is obviously not applicable to complex parts, such as an eye or a face. The contrast between uniform and non-uniform bodies is marked firmly in *Meteor*. IV, e.g., in ch. 10, at 388^{a}13–20; as *Meteor*. IV is largely devoted to the nature and formation of the homoeomers, we would expect an explicit definition of those uniform bodies, but Aristotle prefers to list examples rather than to offer a definition proper:[7]

> By uniform bodies I mean, for instance, stuffs that are mined – such as copper, gold, silver, tin, iron, stone and other such stuffs and materials that have been separated out of them, as well as tissues that can be found

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[6] Perhaps the sole notable (possible) exception to this rule is the famous passage in *Physics* I.4 (187^{b}14–21) that spawned the theory of *minima naturalia* in the Middle Ages and inspired, at least indirectly, a plethora of chemical and quasi-chemical theories in early modern science. It is also worth adding that a rather rare dissenting view can be found in Cooper (2004), a note on Aristotle's concept of *mixis* in *GC* which attempts to refute the traditional (at least since Philoponus) thesis about 'total interfusion'. Cooper's interpretation allows for the possibility that extremely small amounts of stuff could consist of pure earth or pure water etc. in a mixture.

[7] For similar lists of homoeomers in contexts where one would rather expect a formal definition, see *PA* II.2 647^{b}10 ff., part of a general introduction to a mini-treatise on uniform parts, comprising *PA* II.4–9, and *Historia Animalium* I.1 487^{a}2–9, part of a synopsis of types of differentiae (*diaphorai*) among species of animals, where Aristotle is primarily concerned with the distinction between soft and moist uniform parts on the one hand (Peck translates *hugra* with 'liquid', rather than 'moist', but lard and marrow are not exactly liquid), and solid and dry on the other hand (sinew, skin, blood vessel, bone, horn etc.).

> in animals and in plants; for example, kinds of flesh, kinds of bone, sinew, skin, gut, hair, fibre, veins, from which have been composed the complex parts: face, hand, foot and the like; and uniform stuffs that can be found in plants are wood, bark, leaf, root, and the like.[8]

There are two similar lists in ch. 8 ($384^{b}31–385^{a}1$) and in ch. 12 ($390^{b}3–10$) of *Meteor*. IV. All three passages are accompanied by reminders of how these uniform stuffs come about (through the agency of the active factors, hot and cold, on the passive ones, dry and moist or earth and water, in keeping with the precepts put forth in ch. 1) and of how they can be differentiated (through their powers or affections – *dunameis* or *pathē*: hardness, ductility etc.).

It may be useful at this point to sketch the content and purpose of *Meteor*. IV, a treatise that was the object of an impressive number of commentaries from late antiquity through late Renaissance, although it tends to be less widely read today. Homogeneous stuffs play a cardinal role in Aristotle's theory of matter, especially in his discussion of chemical combination, and are central to his explanatory apparatus in the biological corpus. Yet, it is in *Meteor*. IV that we find a detailed and systematic investigation into the nature and formation of both organic and inorganic uniform bodies. It is worth remembering that *Meteor*. IV is not a book about meteorology, even in an Aristotelian sense.[9] Its position after *Meteor*. III may be an accident related to the early tribulations of Aristotle's manuscripts. It has rightly been considered transitional from works that are primarily concerned with the study of inorganic materials (*De Caelo* III–IV, *GC*,[10] and to some extent *Meteor.*

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[8] Translations in this paper are mine unless otherwise indicated.

[9] Aristotelian meteorology covers phenomena occurring in the sublunary sphere due chiefly to the dry and the moist exhalations and including the appearance of the Milky Way, comets, meteors, earthquakes, and what we would consider today to be meteorological phenomena proper (all these topics form the substance of books I–III).

[10] Alexander (2–3 c. CE) suggested (179.3 ff.) that, as far as the subject matter goes, *Meteor*. IV would more naturally come after *GC* (for a discussion of his argument, see Natali (2002), 45–48. This suggestion becomes all the more appealing if we accept, with Joachim (1926), xxxvi–xvii, that in *GC* Aristotle is concerned primarily with the *genesis* and *phthora* of the homoeomers, his discussion about the generation and destruction of the simple bodies being relevant to the former topic in so far as the simple bodies are the proximate constituents of the homoeomers. By contrast, Olympiodorus, agreeing roughly with Ammonius (in Olympiodorus 6.19 ff.) argues (273.21–274.1) that book IV is placed rather naturally after *Meteor*. I–III, since Aristotle must have planned

I–III) to Aristotle's biological works such as *Parts of Animals* and *Generation of Animals*. This idea has become common currency with the publication of Furley's 1983 paper, although the point was possibly suggested by Aristotle himself, in the first chapter of *Meteor*. I, a chapter that is both retrospective and programmatic.[11] Besides, in the final chapter (ch. 12) of *Meteor*. IV, at 389^{b}23–28[12] and 390^{b}15–23, Aristotle explicitly states that, after dividing homoeomers into kinds (*genē*) in the bulk of this book, his next task is to consider organic homoeomers individually (*kath'hekaston*); a crucial factor in determining their nature individually will be, in his biological corpus, the use of functional accounts, involving systematic appeal to final causes.

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to deal with the nature and affections of the elements in the following order: the elements as entities not subject to generation (*De caelo*); the generation of the elements (*GC*); ways in which the elements can be affected (the *Meteorology* – presumably all four books, the fourth one simply expanding – in general fashion – on the discussion, at the end of book III, about some of the inorganic homoeomers, i.e. metals and stones). For a commentary on Olympiodorus' argument, see Viano (2002), 67–69.

[11] In *Meteor*. I.1 (339^{a}6 ff.) Aristotle describes the overall trajectory of his research by saying that, after offering his explanations of meteorological phenomena, he will provide general and particular accounts of animals and plants. Both the 'general' (*katholou*) and the 'particular' (*chōris, kath' hauto*) approaches can be found in Aristotle's extant biological corpus and may have been present also in some lost treatises on botany, especially if Theophrastus' own works roughly reflect the nature of their Aristotelian models. Still, *Meteor*. IV too is overtly meant to offer a generic account of uniform bodies; its 'particular' counterpart can be found in *PA* and in *GA*, in so far as the organic uniform parts are concerned (and, we can conjecture, Aristotle probably also intended to give a more detailed account of mineral uniform bodies, although, as Olympiodorus assures us at the outset of his commentary on *Meteor*. IV, Aristotle never actually carried out that project).

[12] The beginning of *Meteor*. IV.12 (389^{b}23–28) reads: 'Since we have made distinctions regarding these issues, let us say what flesh or bone or any of the other homoeomers is separately; for we can see – by their generation – from what elements the nature of the homoeomers has been constituted, what their kinds are and to which kind each homoeomer pertains.' This passage seems almost echoed by the end of *PA* II.5: 'We have stated, regarding blood, serum, and soft and hard fat, both what each of them is, and owing to what causes each of them is' (trans. Lennox) and may be reminiscent of the end of *Meteor*. III: 'I have discussed then all these stuffs [i.e. metals and stones] in general, and now I should tackle and inquire into each kind individually.'

Thus, chapter 12 gives prominence to one of the emblematic motifs of Aristotle's natural philosophy. The study of organisms and of individual parts should combine an inquiry into their material constitution (a task largely assumed by *Meteor*. IV at a generic level) with an account of the functions that essentially determine the nature of those parts (this being fulfilled by various segments of Aristotle's biological works). The views expressed in ch. 12 are instrumental in our correctly placing *Meteor*. IV within the Aristotelian corpus (the 'missing link' between works dealing with the inorganic and works devoted essentially to biology), to fully grasping Aristotle's resort to conditional necessity and to our correctly assessing the role of the homoeomerous bodies within a biological context.

However, the actual, dominant achievement of *Meteor*. IV lies elsewhere: most of the fourth book (chs. 1–11) is devoted to the study and division of kinds of homoeomers (or homogeneous stuffs, uniform bodies) and of various effects of heat and cold on such uniform stuffs – an enterprise that will turn out to be profitable in the study of simple and complex 'parts' in treatises like *PA*, where Aristotle does not have to embark on lengthy and detailed inquiries into the nature of uniform bodies every time he considers the material nature of some tissue, such as blood or flesh. Instead, he can conveniently glimpse back, as it were, at his earlier investigation in *Meteor.* IV and, based on the perceptible properties of some tissue, he can presumably determine its composition: watery, mostly earthy etc.[13] *PA* II and *GA* V,[14] to mention only the most obvious examples, contain numerous such details that appear to draw on *Meteor*. IV.

THE OFFICIAL DOCTRINE: ALL HOMOEOMERS ARE COMPOUNDS

I have emphasized some of the connections between the *GC* theory of *mixis* and the *Meteor*. IV discussion about *ta homoiomerē* not only in order to stress the complementariness – in key respects – of these two texts, but also to

[13] This is in keeping with the 'economical' approach that – as Lennox (2001) has demonstrated – is displayed *within* the *PA* itself: Aristotle starts, in *PA* II, with an investigation into the nature of uniform parts, before engaging in a discussion of non-uniform parts in books III, IV (had he done otherwise, he would have had to account for the nature of tissues when tackling each complex organ).

[14] However, *Historia Animalium* III (largely devoted to the uniform parts of blooded animals) exhibits virtually no interest in the 'chemical' composition of the organic uniform stuffs.

introduce a passage from *GC* that is central to my argument. In this *locus classicus*, Aristotle reveals the scope of his discussion about uniform stuffs and, implicitly, its relevance to his natural philosophy and his science. It turns out that not only are genuine chemical combinations thoroughly uniform, but these uniform stuffs, which encompass the whole realm of nature, contain (*dunamei*,[15] of course) *all* four simple bodies – earth, water, air, and fire. We have to assume that this is the case, whether the actual uniform compounds in the sublunary world were the result of the blending of simple bodies or of other uniform compounds (e.g., bronze, an alloy of copper and tin) whose composition could in turn be analyzed ultimately into the four simple bodies. Ch. 7 of *GC* II provides an account of how simple bodies can mix to form homogeneous compounds displaying emergent properties that are generated at various points along the hot-cold and moist-dry continua; the next segment, ch. 8, is meant to indicate how pervasive this phenomenon, *mixis*, is and to prefigure some of the points that will be developed in chs. 9 and 10 (on the causes of coming to be and passing away). Here is the opening passage of *GC* II.8:

> All the mixed bodies (*ta mikta*), the ones that are around the central region, are composed of all the simple bodies. For earth exists in all [compounds in the central region] because each [simple body, including earth] exists chiefly and in greatest supply in its proper place, while water [can be found in all compounds in the central region] because what is a compound (*to suntheton*) must be delimited, and among the simple bodies only water is easily delimitable, and, moreover, even earth could not hold together without the moist, which is what keeps it together; for, if the moist were completely removed from it, it would fall apart. Thus, it is for these reasons that earth and water exist in [bodies that are around the central region], whereas air and fire [can be found in them] because

[15] A recent and careful comparison between the *GC* account of *mixis* and *Meteor*. IV is provided by Viano (2006). She rejects Joachim's interpretation (1926), 176, 180–181, which follows Philoponus and Zabarella, namely that *dunamis* in this context should be understood as a sort of diminished second potentiality, similar to a drunk geometer's diminished ability to solve a problem. Instead, Viano (2006), 126 suggests that what Aristotle must have had in mind were the sort of intrinsic *dunameis* listed and defined in chapters 8 and 9 of *Meteor*. IV: liquefiable, breakable, splittable, combustible etc. She adds that such qualities are due to some extent to the thermic processes which contributed to the mixing and to the formation of a new uniform body. This is certainly sensible but does not completely dispel the fog shrouding the use of *dunamei* here.

> they are contraries of earth and water (for earth is the contrary of air and water of fire, in so far as a substance can be the contrary of another substance).[16]

Aristotle's formulations are typically elliptic and the passage is occasionally baffling (e.g., *ta mikta* and *to suntheton* appear to be used synonymously here despite the fact that the two terms correspond to concepts – *mixis* and *sunthesis* – that are markedly distinct in *GC* I.10 as they correspond to chemical combination and to aggregation or mechanical mixture respectively). Besides, it is not clear that *everything* in the sublunary region is composed of *all* four simple bodies, given that all of these claims appear to be qualified by the formula 'around the central region' (the contrast is obviously with what is closer to the orbit of the moon but still in the sublunary sphere, which raises potentially interesting questions about the two exhalations, as we shall see in the final section of this paper).

Still, the drift of the passage is clear enough and I think Williams (1982), 51 is quite right in entitling his translation of ch. 8 'Each Element Present in Every Homoeomer'. The first sentence of ch. 8 may seem somewhat ambiguous, since *the sum total* of the compound bodies (around the central body, i.e. earth) could consist of all four simple bodies, without this entailing necessarily that *each* uniform compound contains *all four* simple bodies in a certain proportion; this possible ambiguity, however, is dispelled by the next sentences. Different reasons are offered for the presence of (a) earth, (b) water and (c) air and fire in all the homoeomers situated in the proximity of the Earth. The ubiquitous presence of earth in the central region of the universe is due to its abundance in its natural place; water is necessary for the cohesion of all uniform bodies and their acquisition of definite shapes;[17] air and fire too are present in all homoeomers, since, as we learn from the next few lines, comings about are due to contraries (*hai geneseis ek tōn enantiōn eisin*). What Aristotle must have in mind here is that substances (*ousiai*), specifically the four simple bodies, are conceivable as contraries in so far as they are characterized by opposite pairs of basic qualities (dry and cold, i.e. earth *vs* moist and hot, i.e. air; moist and cold, i.e. water *vs* dry and hot, i.e. fire) and are theoretically reducible to four dominant properties: water to cold and fire

[16] $334^{b}31–335^{a}6$.

[17] Regarding the adaptability in shape of the moist, see *GC* II.2 $329^{b}31$, *Meteor*. IV.4 $381^{b}28–30$.

to hot; air to moist and earth to dry.[18] While the reasons for the presence of earth and water in all compounds sound reasonable within the bounds of Aristotle's cosmology, the one offered for the notion that air and fire too must be found *dunamei* in all compounds is less cogent. The illustration meant to bolster his point is that each compound is nourished by an array of things partly similar to its constitution (for instance, plants need both water and earth, 335^{b}11–14; cf. *GA* III.11 762^{b}12), although it is notable that air and fire are not mentioned in this example. Judging by its larger context, this argument for the presence of fire and air in all compounds is chiefly but perhaps not exclusively an expedient intended to ensure a smooth transition to the distinction made in chs. 9 and 10 between the four types of causation. In light of chs. 9 and 10, Aristotle's ch. 8 glimpse at the compounds around the center of the universe acquires greater significance: it points out the effect of the principal efficient cause responsible for the phenomena in the sublunary world – the sun's continuous movement along the ecliptic (ch. 10).

I will pass over the metaphysical significance of ch. 8, interesting though it might be (involving the preservation of the matter-form unity and the distinction between nourishment which is essentially matter and that which gets nourished, namely the shape or form taken together with matter), since my goal here is rather to bring attention to and to briefly analyze crucial passages where Aristotle argues for the 'official doctrine' that all (uniform) compounds are chemical combinations. Let me now tackle another such passage, which shares much with the one that I have just examined. As I mentioned before, *ta homoiomerē* are not defined explicitly and technically in *Meteor*. IV, but the passage that comes closest to offering a definition is the following one:

> … Heat exists in all bodies because they are crafted by [heat and cold], and cold exists in some in so far as the heat is lacking. So, since these are present in virtue of their being active, moist and dry in virtue of their being passive, the mixed bodies (*ta koina*) partake of them all. Therefore, the homoeomers consist of both water and earth, in the case of plants and animals, and, as for stuffs that are mined, such as gold, silver and the like, they consist of [earth and water] as well as of the enclosed exhalation pertaining to each of the two [i.e. to earth and to water], as has been mentioned elsewhere (IV.8 384^{b}26-385^{a}1).[19]

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[18] This conforms to *GC* II.3 331^{a}1–6, but may be slightly problematic for Aristotle since it is 'water' and 'the moist' / 'moisture' (rather than 'cold') that are used interchangeably in this very passage and throughout *Meteor*. IV.

[19] See *Meteor*. III.6.

These lines are intended to preface a division of (especially solid) homoeomers based on intrinsic or primary dispositional properties – breakable stuffs, flammable stuffs etc., as opposed to a possible division along the lines of colors and other essentially perceptible properties. The idea that all simple bodies are present in all homoeomers is slightly attenuated here, since Aristotle notes that all four basic opposites (hot, cold, moist, dry)[20] along with only two of the simple bodies, earth and water, and the exhalations (presumably in the case of stones and metals alone) are present in the homoeomers. Yet, even if he is not concerned here with air and fire as quasi-universal ingredients,[21] the discrepancy with the passage from *GC* II.8 may only be apparent (after all, even in *GC* II.8 only earth and water are explicitly named as 'nourishment' for plants). In any case, this possible discrepancy is not particularly troubling, given that Aristotle's 'chemistry' in *Meteor*. IV

[20] Cf. *PA* 646^{a}14 ff. For a helpful discussion about Aristotle's apparent hesitation between treating the homoeomers as compounds of simple bodies and regarding them as consisting of dry, moist and the other basic opposites, see Rashed (2005), cxxvi–cxxix and *passim*.

[21] Alexander (213.10–12) believes that Aristotle must have meant that uniform compound bodies are combinations of all four simple bodies and that Aristotle may have mentioned only earth and water here because they tend to predominate in homoeomers. This is less than obvious, though, from the text and its context. There are also other passages that suggest that air and fire are only scantily present in most homoeomers, if at all (thus at 382^{a}7 ff. Aristotle points out that animals live only on land and in water, which are also the stuffs from which organisms are constituted, but not in air or fire, which seems to imply that air and fire are largely absent, with some exceptions, from their material constitution; by the way, in *GC* II 7, 334^{b}5 Aristotle does speak, albeit tentatively, about fire and earth as the ingredients of flesh, but he apparently takes his own example *cum grano salis*). Frede (2004), 311 suggests that 'The special importance that is attributed to two of the simple bodies, namely earth and water [i.e. in *Meteor*. IV] clearly comes from the need to keep simple the basic principles that underlie the wide variety of phenomena.' That Aristotle simplifies his chemical formulas, so to speak, for the sake of clarity and simplicity would be a more convincing suggestion if he referred exclusively to earth and water in *Meteor*. IV; yet when a reference to air is required by the explanation of the behavior of certain stuffs (oil, wood etc.), he mentions it without hesitation. His overall division into kinds of stuffs would likely not become very complicated if he were to also invoke air as an elemental constituent more systematically. I submit that the main (not necessarily the only) reason why he does not do so is because such homoeomers form a relatively small set – in so far as he ventures to determine the airy nature of certain uniform materials.

and in his biological corpus relies heavily on the ratio between earth and water or dry and moist in the uniform stuffs, whereas air and fire play a much more discreet role there. More importantly, both passages contend that the four basic opposites (not just the simple bodies resulting from their pairings) must be present in all homoeomers. Finally, the exhalations (not mentioned in *GC*, but pivotal in *Meteor*. I–III and looming in the background of *Meteor*. IV) are probably nothing but the simple bodies at various stages in their process of transformation (more on this, later in this paper), one of the exhalations being smoky or fiery, the other one being moist.

The inferential *oun*, 'therefore', after 'the homoeomerous bodies' implies not only that all compound bodies include (*dunamei*) moist and dry or water and earth, but also that (all the)[22] homoeomerous bodies are compounds. If so, he means that each and every type of homoeomer includes all four opposites, rather than that one can find all four opposites *in the sum total* of homoeomers, without it being necessary that all four opposites be present *in each and every* type of homoeomer (although note that cold – as an active factor, not as mere privation – is present in some, *tisi*, maybe not all, uniform bodies).

This seems largely to square with *GC* II.8 as well as with the passage in ch. 4 of *Meteor*. IV (381^{b}24–382^{a}4) where Aristotle reminds us that the passive principles of physical bodies are the moist and the dry (*hugron kai xēron*) and that 'the other things' are combinations of dry and moist. He curiously enlists Empedocles in his service, quoting from his poem *On Nature* ('gluing the barley meal with water', 382^{a}1) a passage which conveys the idea that water is necessary for ensuring cohesion and for preventing solids from disintegrating.[23] His next comment seems to qualify his initial, apparently universal, claim (covering all homoeomers, solid and liquid), by saying that 'definite bodies' (*hōrismena sōmata*), which presumably refers only to solids,[24] include both water and earth in their composition. Even so, this passage, along with the ones I quoted from *GC* II.8 and *Meteor*. IV.8, argues quite firmly for the view that all the homoeomers are compounds and that at the very least they include earth and water (*dunamei*) if not all four simple bodies – and thus all four basic opposites.

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[22] Cf. below, *ek men oun hudatos kai gēs ta homoiomerē sōmata sunistatai*… Like *koina* above, *homoiomerē* has the definite article *ta*, which possibly adds the strength of a generic or even universal claim.

[23] This reinforces the thesis proposed in *GC* I.10 as well as *Meteor*. IV.8.

[24] See on this Düring (1944), 78.

As I have already mentioned, this is also the orthodox view generally embraced by commentators when tackling the nature of the homoeomers. The problem is that Aristotle himself is far less consistent in this respect than he may seem to be and the fluidity of dominant aspects of his conception of uniform stuffs – a work in progress, one might say – will hopefully be apparent from the following list of passages.

NOTABLE EXCEPTIONS

There is strong evidence in *Meteor*. IV that Aristotle was not fully committed to his own theory that all homoeomerous bodies are composed of the four simple bodies or at least of both earth and water, after all. It turns out that some uniform stuffs *consist of only one element*, specifically only of earth or only of water. Here is a list of examples from *Meteor*. IV (in the order in which they appear there) which, I believe, call into question the tempting but perhaps false view that Aristotle consistently considered *all* uniform bodies to be compounds and, furthermore, considered them to be combinations of all four simple bodies or at least of earth and water in various proportions.

1. Absence of water / moist (pure earth?)

Ch. 3 of *Meteor*. IV includes a discussion of boiling (*hepsēsis*), 380^{b}13–381^{a}12, which is a type of concoction (*pepsis*) that affects the properties of homoeomers through the moist heat of the undetermined stuff present in the moisture of a homoeomer. In this context, we find that there are uniform bodies that *cannot* be boiled because they contain no moisture at all (a rather emphatic formula: *en hōi mēden estin hugron*, 380^{b}25), for instance certain stones, or contain moisture but are too dense to be boiled, for instance wood. Therefore, certain kinds of stones appear to be completely devoid of water and probably to consist only of earth, although this does not seem to prevent them from maintaining their cohesion, which contradicts some of the claims made in *GC* II.8 and in *Meteor*. IV.4.

In ch. 6 Aristotle deals, among other things, with solidification as a result of the complete evaporation of water from a compound, a process that is responsible, for example, for the production of baked clay (383^{a}20–21, cf. 383^{b}11): 'Therefore, things that are soft but are not moist do not thicken but solidify, as the moist leaves them, for instance baked clay (*optōmenos keramos*).' There is no qualification implied in this process of evaporation, which likely suggests that what is left – namely, baked clay – lacks moisture altogether and perhaps is 'pure' earth, paradoxically displaying, besides cohesion, a specific

set of secondary dispositional differentiae. This reading is supported by the end of ch. 7 (384^{b}20–22) where Aristotle affirms that baked clay consists of earth only (*gēs monon*).

In ch. 8, in a succinct discussion of solidification, Aristotle notes (385^{a}28–31) that 'Some stuffs are dissolved by the moist because the moist is absent [from their constitution] (*hugrou apousiāi*), unless they have contracted such that their pores have been left too small for the particles of water [to penetrate them], which is the case, for example, with [baked] clay; yet, if this is not so [i.e., if their pores do not prevent water from entering], they are all dissolved by the moist, for instance, soda, salt and mud reduced to earth.' A few lines further (385^{b}1–3), he speaks again of uniform stuffs that are devoid of watery moisture: 'Incapable of solidification are those stuffs that do not have watery moisture (*hosa mē echei hugrotēta hudatōdē*) and do not consist of water (*mēde hudatos estin*) but consist more of the hot and of earth, for example honey and must (for they are in the process of boiling, as it were)…'

At the beginning of ch. 9, in a passage (385^{b}6–12) dealing with things that are softenable by heat (*ta malakta*) we learn that this material disposition is present in uniform bodies that contain predominantly earth, but *not only* earth as it is the case with soda and salt, from which *all* moisture has evaporated (*exikmastai pan*) and thus end up containing *only* earth;[25] also, if a body is to be softenable by heat, its moisture must not be present in disproportionately small quantity, like in potter's clay (to be understood: unbaked clay), *keramos*. Significant here is the sharp distinction between earthy bodies that include a very small amount of moisture and those that truly lack any moisture whatsoever, which, given the absence of references to fire and air, indicates the possibility that some bodies are made just of earth.

In ch. 10, at 388^{b}12–24, Aristotle distinguishes solids that contain only earth both from solids that contain only water (e.g., ice) and from solids which are predominantly earthy but from which moisture has not evaporated completely. Here is the passage on what appear to be purely earthy solids:

> …Those stuffs [that are solidified] by heat, consist of earth, for instance clay, cheese, soda, salt; those which are solidified by both [heat and cold] consist of both [earth and water] (such are the stuffs solidified by cooling, as a result of the lack of both heat and moist; for salt and [the other] stuffs

[25] Cf. ch. 9 in book VII of *Problems* (whose authorship is a notoriously thorny issue, although it generally includes reflections on genuinely Peripatetic theories), where salt, dust and niter are suggested to lack moisture.

> that are made purely of earth (*hosa eilikrinē gēs*)[26] solidify solely due to the lack of the moist, while ice solidifies only due to the lack of heat). For this reason they are solidified by both [heat and cold] and contain both [earth and water]. Those stuffs from which [the moist] has been evaporated entirely (*hapan exikmasthē*), such as [baked] clay and amber – all of them consist of earth (for amber as well as the stuffs called 'tears' exist due to a process of cooling, e.g., myrrh, frankincense and gum; amber too seems to belong to this kind and is the result of solidification as indeed demonstrated by the animals trapped in it; the hot, forced to leave by the [cold water of] the river evaporates the moisture, as it happens with the natural heat of boiled honey, when dropped into water).

Just as water or moisture seems to be completely absent from certain homoeomers, judging by a number of generally unequivocal comments in *Meteor*. IV, earth is absent from others, as we can see from the following list.

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[26] Instances of such genitive can also be found in *PA*, e.g., at 650^{b}18 and 651^{a}8. This rather curious genitive accompanied by *einai* or implying an *einai* occasionally suggests a predominant (rather than exclusive) ingredient; for example, wood consists of earth and air (ch. 7, 384^{b}15–16: *ta de xula estin gēs kai aeros*), although not exclusively, since we know – and Aristotle makes this point in no uncertain terms – that wood is also composed of water or the moist. On other occasions, however, this type of genitive seems to simply indicate an exclusive rather than just a predominant ingredient; e.g., at 10, 389^{a}1–2: stuffs dissolved by water consist of earth (*tauta de gēs*), whereas stuffs that are not dissolved or melted by either water or fire consist of earth or of both (*tauta ē gēs ē amphoin*); in this case, logic would dictate that *gēs*, as opposed to *amphoin*, means 'only of earth', unless by *amphoin* Aristotle does not mean just 'water and earth' but 'water and earth in a rather balanced ratio', which would leave open the possibility that *gēs* is roughly the semantic equivalent of 'mainly of earth, in a composition in which water is in disproportionately low amount'. Such an interpretation, however, while not entirely impossible, does not appear to be warranted by the text of *Meteor*. IV. That this type of genitive + *einai* (or implying *einai*) is unlikely to *always* mean '*predominantly* of (earth / water)' is also suggested by Aristotle's addition of *pleon* or *mallon* to the genitive (which would be superfluous if the genitive itself would already imply predominance in such contexts): 383^{b}20, 384^{a}12, 385^{b}3 etc. On the other hand, this type of genitive clearly does not *always* indicate an exclusive ingredient either, since sometimes Aristotle feels compelled to add *haplōs* or *monon* for the sake of clarity (e.g., *PA* II.2 649^{a}31 ff).

2. Absence of earth / dry (pure water?)

According to ch. 3, 380[a]34 both dry and moist are necessary for the process of concoction (marked in part by thickening of the organic uniform body undergoing that change), concoction being one of the most pervasive organic processes in nature, according to the Stagirite. A similar point is made again in ch. 6 (383[a]11–13): 'For this reason, such stuffs [i.e. those consisting of water] do not thicken when they are solidified, for thickening occurs when the moist departs and the dry becomes more compact; water (*hudōr*) alone among liquids does not thicken.' Lee, who translates *hudōr* with 'watery liquids' is probably right to assume that *hudōr* is not just 'water' here; in any case, water and watery liquids, while not identical, are close enough to display very similar dispositional qualities (see, for instance, ch. 5 of *Meteor*. IV). Implied here is the possibility that certain liquids lack earth (or dry). This passage in ch. 6 comes in the context of a survey of conditions that cause the liquefaction and solidification of the stuffs consisting of water (*hosa hudatos*, 383[a]7), as well as of combinations of earth and water (*hosa de koina gēs kai hudatos*, 383[a]14). Since these two types of uniform stuffs are clearly distinguished here, the first one (see especially 383[a]7–13) can be taken to refer to liquid uniform stuffs that are *not* compounds consisting of earth and water and probably contain water alone (maybe at slightly different points along the continua between the basic opposites, which might explain the distinction between water and various forms of water or watery liquids).

Ch. 10, much like ch. 6, appears to convey the notion that there are liquids (apparently distinguishable from each other) that are made entirely of water (388[a]30 ff.), their general and chief mark being a dispositional differentia: they tend to evaporate easily (stuffs that are less liable to evaporate consist of earth or of a combination of earth and water, like milk; or of earth and air, like honey;[27] or water and air, like oil). A few lines further into the same ch. 10 (388[b]9 ff.), we read that stuffs, such as oil and sweet wine, which are thickened both by heat and by cold consist of several constituents or simple bodies (*koina pleionōn*). By implication, this passage allows for the existence of bodies made of only one element, including those that consist only of water. This impression is strengthened by the conclusion at 389[a]3–6:

> If, then, all stuffs are either liquid or solid (and the stuffs characterized by the qualities just discussed are among these [i.e. liquids and solids]) and there is nothing in between, then all the properties have been discussed

[27] If we are to accept Vimercati's reading; see Lee (1952), 360, note b.

> through which we can determine whether a stuff consists of earth or of water or is a compound consisting of several [simple bodies] (*ē pleionōn koinon*), and whether it has been constituted by fire or by cold or by both.

Finally, let me mention a passage in ch. 11 (at 389[a]29–[b]7) which reminds us that cold is not simply a privation (of warmth), but in a way it is also matter; among other things, he notes here that cold is a common and defining characteristic of earth and water and, consequently, bodies which consist of either element alone (*hekaterou haplōs tou stoicheiou*) – earth and water, which best exemplify the dry and the moist – are rather cold. As for compounds (*hosa de koina*), they tend to be warm. All this seems to indicate that some homoeomers consist of only one element, for example, just of earth or just of water.

This is not an exhaustive list of such examples, but I hope that it is sufficient to show that Aristotle's theory regarding the nature of homoeomers is more tentative than generally assumed and may occasionally entail serious cases of inconsistency within his treatment of matter.[28] One is left with the strong impression that Aristotle's theory of matter was still a work in progress when he was writing *Meteor*. IV – certainly more so than modern commentaries tend to state or imply. Perhaps this should not come as an utter surprise, since, among other things, his *Meteor*. IV is not obviously or thoroughly coherent,[29] and its extant form seems to be the result of successive revisions by the Stagirite.

In the passages that I have listed and briefly analyzed here he makes several general claims, which are complementary and sometimes coextensive:

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[28] The impression of inconsistency cannot be dispelled by questioning the authorship of *Meteor*. IV. Lee (1952), Furley (1989), Lewis (1996) and others have put any doubts about the authorship of this book to rest convincingly and, I think, definitively. It would also be implausible to take those passages to be interpolations in an otherwise Aristotelian text, since they are central to the explanation of so many specific phenomena discussed in *Meteor*. IV and of the division of the homoeomers according to their chemical constitution, physical microstructure and to their dispositions.

[29] To mention just a few puzzles related to the structure and content of *Meteor*. IV: How are chapters 2 and 3 (dealing with concoction and inconcoction, *pepsis* and *apepsia*) to be connected with the subsequent chapters of this book? Why did he devote two sections (chs. 5–7 and ch. 10) to the ratio between earth and water in various homoeomers? How is the sole mention of the exhalations in *Meteor*. IV (384[b]33) to be reconciled with the rest of the explanatory apparatus (relying on references to water and earth or moist and dry)?

a) earth or water could be absent from the composition of certain uniform stuffs; b) some homoeomers consist of only one simple body, while others are compounds; c) more specifically, there are homogeneous stuffs that consist only of earth or only of water. *Meteor*. IV, as we have seen, seems to indicate that pure stuffs can only be found among inorganic homoeomers; the organic ones seem to always be compounds, involving a higher degree of chemical complexity and the presence of internal heat, *emphuton thermon*. Some of these passages are more explicit than others, but, considered both individually and as a collection, they point rather emphatically to the possibility that *not all* homoeomers are compounds (and that at least some of the uniform compounds do not consist of all four simple bodies, but maybe just of earth and water). Thus, quite a few passages in *Meteor*. IV signal a distinction between two sorts of uniform bodies – uniform compounds and simple or pure stuffs (*actually* consisting only of water or only of earth, in contrast with the potential presence of simple bodies in chemical combinations).[30] This entails that a universal definition of the homoeomers should not include a reference to composite nature (although it is clear from the examples discussed by Aristotle in *Meteor*. IV, *PA* II, *GA* V etc. that *most* homoeomers are indeed compounds). Furthermore, this is not simply an isolated and whimsical point, subsequently disavowed in Aristotle's works; quite to the contrary, in the biological works, in passages clearly echoing *Meteor*. IV,[31] he still seems to maintain that some uniform stuffs consist of only one simple body.

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[30] Remarkably, this distinction seems to correspond, on a higher level of complexity, to the differentiation that Aristotle makes explicitly between types of anomoeomers or non-uniform parts (*PA* II.1 646^{b}30–32):'…The non-uniform parts are capable of having been composed from the uniform parts, both from many of them and from one, as with some of the viscera; they are complex in configuration, though generally speaking they are composed of one uniform body (*polumorpha gar tois schēmasin ex homoiomerous onta sōmatos hōs eipein haplōs*)' (trans. Lennox).

[31] See, e.g., *PA* II.2 649^{a}31–33, *hosa hudatos monon…hosa de gēs*, 'the stuffs made only of water…the stuffs made [by implication: only] of earth'; the significance of this qualification (*monon*) is further emphasized by another and quite different qualifier (*mallon* in *hosa gēs mallon*, the stuffs consisting mainly of earth). Now, it is empirically evident that even compounds in which water predominates, but is not exclusively present, will be solidified by cold, but Aristotle does not appear to have thought of compounds when he used *monon*. What is also noteworthy in this passage is that it undoubtedly reflects *Meteor*. IV and the law-like statements one can find there (in this case: stuffs composed solely of

If I am right that earth and water can exist separately anywhere in the sublunary sphere, whether diffusely and amorphously or as lumps or, more intriguingly, as artifacts (albeit probably not as tissues or parts of animals), then a number of additional questions pertaining to the nature and formation of the homoeomers need to be answered – and that is the task that I will assume in the next and final section of this paper.

RELATED PROBLEMS AND TENTATIVE SOLUTIONS

So far I have attempted to prove that Aristotle's claim regarding the combination of the four (sublunary) simple bodies is often decidedly more relaxed than many of his modern commentators seem to assume. It should be clear by now, I hope, that not all homoeomerous bodies include all four simple bodies *dunamei* (in various ratios); moreover, their nature does not appear to even reflect Aristotle's more qualified statement in *Meteor*. IV.8, where he explicitly posits the necessary presence of water and earth in all uniform stuffs (along with the exhalations, in some of them). In short, Aristotle does not appear to have settled on a definitive theory in this respect, leaving wide open the possibility that uniform stuffs could consist of combinations of only some of the four simple bodies or, in some cases, could indeed consist of only one such body. Assuming that this is correct, I would like now to consider three adjacent issues: How are homoeomers consisting, e.g., only of earth (amber, myrrh, salt etc.) generated? What is a pure stuff, given rather puzzling categories of uniform stuffs, such as the exhalations and forms of earth or water, and a possible distinction between 'theoretical elements' and 'practical elements'?[32] How can one account for different behaviors among uniform bodies consisting of the same one element (e.g., earth)?

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water are solidified by cold, whereas stuffs consisting – presumably only – of earth are solidified by heat or by fire). This supports my view that Aristotle's frequent references to pure earth and pure water do not form an aspect that pertains idiosyncratically to his theory of matter in *Meteor* IV and was duly abandoned after *Meteor*. IV had been written, but a feature that is profitably utilized in later writings, such as *PA*. He points out in this very passage that he previously discussed such dispositional differentiae more clearly elsewhere – *en heterois* – and, again, this is a fairly clear reference to *Meteor*. IV, as Peck (1937), 128, note a: 'See *Meteor*. 382^{b}31 ff., 388^{b}10 ff.' and Lennox (2001), 195: 'Cf. Meteor. IV.6 383^{a}26–^{b}17, and 7 384^{b}2–23', plausibly point out.

[32] The terminology of a distinction of 'theoretical elements' and 'practical elements' is from Bolzan (1986), 135.

I. If homoeomers consisting of only one simple body are possible, how are they generated?

Some of the homogeneous stuffs that, according to Aristotle, consist only of water or only of earth clearly start out as compounds of earth and water. An example is *keramos* or (unbaked) potter's clay, which loses its moisture entirely as a result of a drastic process of separation of water from that combination, when clay is exposed to intense heat in the kiln and the external heat drives off the internal heat along with the moisture (more specifically, the moisture is thoroughly eliminated from clay, through a peculiar kind of transpiration, followed by evaporation proper). In the case of natural stuffs like salt, it is likely that natural evaporation (e.g., of moisture from brine) led to the formation of homoeomers consisting entirely of earth. Aristotle tells us explicitly that evaporation (due to the expulsion of internal heat and moisture by cold) accounts for the formation of amber, myrrh, frankincense and gum, which presumably contain no water. *Mixis* remains important in this context, but it is the process of separation that ultimately leads (under specific thermic conditions) to the eventual formation of a uniform stuff consisting of only one element.

As I have mentioned, Aristotle's treatment of uniform bodies or *ta homoiomerē* relies heavily on the theory of *mixis* outlined in *GC* I.10, where Aristotle points out (328^{a}11–12) that genuine composition must be uniform (*to michthen homoiomeres einai*). He goes on to say that, just as a part of water is water, any part of a uniform compound should be a uniform compound (i.e. of the same kind as the whole). If such a homogeneous blend – for instance between liquids like water and wine – is to be possible, a number of conditions have to obtain: among other things, 'When there is a certain equilibrium among their potencies (*tais dunamesin*), each one changes from its own nature to the one that dominates, and does not become the other, but rather becomes something in between and common [to both of them]' (328^{a}29–31). Finally, the stuffs to be mixed must display contrariety (*enantiōsin echei, GC* I.10 328^{a}32, cf. *GC* I.7–9), since they should be able to act on each other. *GC* II.2, 7 and *Meteor*. IV will flesh out these conditions, which are only sketched in *GC* I.10, and will deal in expectedly qualitative fashion (or, one might say, in vaguely quantitative fashion, by appealing to the more and the less) with the correlation between the ratio among the constituents and the defining properties of the resulting uniform combination.

Still, the question remains: why does thorough mixing not involve passing away?

Part of the answer lies obviously in the mutual alteration of the corresponding qualities belonging to the mixable bodies; as a result of this

peculiar type of alteration (in which each ingredient plays the dual role of agent and patient), the constituents are unified into a compound which displays a certain balance between the respective original qualities of those constituents (rather than those qualities being utterly eliminated or replaced etc.). This, however, may not be a complete answer. Another part of the answer can be detected in Aristotle's wording and in the structure of that important passage in *GC* I.10. After contending, at 327^{b}23 ff., that the ingredients persist *dunamei*[33] in the new compound and have not perished (*ouk apolōlota*), he reminds us that this is a difficulty he faced earlier (viz. how is mixing possible if the ingredients disappear etc.) and points out that the original constituents existed separately before being combined thoroughly into a uniform body and can be separated again (*dunamena chōrizesthai palin*). In other words, *mixis* is a reversible process. Finally, he slightly reformulates his first point by saying that the original bodies and their qualities are not destroyed (*oute phtheirontai*), but rather their capacity is preserved (*sōzetai gar hē dunamis autōn*). Given the emphatic reference to separation, which connects the two formulations of this central point about *mixis*, and perhaps, to a lesser extent, the use of *dunamena* between the two occurrences of *dunamis*, Aristotle seems to suggest that what prevents *mixis* from being a form of *phthora* is that the original ingredients can in principle be recovered (and thus their *dunameis* can be fully restored). The constitutive ingredients of a uniform compound can be themselves compounds (tin and copper could be separated from bronze), but if (some of) the ingredients are simple bodies, then a compound homoeomer could, through some form of separation, be reduced to pure earth and pure water. All textual indications are that Aristotle meant such a process, and that his talk about separation was not to be taken merely abstractly or theoretically (as, for instance, one could only theoretically analyze, say, earth into dry and cold).[34]

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[33] The use of *dunamei* in the *GC* I.10 treatment of *mixis* is curiously echoed by *Meteor*. II.9 369^{a}13–15 in a discussion about exhalations, which are always mixed together in various ratios.

[34] Alexander explains this type of separation as a reverse process of alteration, involving specific effects of the active factors – heat or cold – among other things, and even offers some rather interesting experimental proof (*De mixtione*, 231.30–232.12). As he puts it (in Todd's translation, 1976, 157): '…[S]o must it be understood that agents which separate constituents from which blends have been formed also do not separate what is actually inherent in [blends] but cause an alteration by a specific force [*dunamei tini*], and actualise bodies that as a result of blending are present in them in potentiality.'

Elements can, then, exist in pure form, for instance as a result of such – natural or artificial – separation. Still, maybe a qualification becomes necessary here: pure earth (in its various forms or *eidē*), while not a compound, is not to be confused, on the other hand, with a certain paradigmatic notion of earth that may indeed be purely theoretical. If it is such 'theoretical elements' (rather than their empirical manifestations) that Aristotle had in mind when proclaiming that simple bodies cannot exist on their own, then there may still appear to be a way of reconciling those statements (in *GC* II.8 and *Meteor*. IV. 4 and 8) with the plethora of passages in *Meteor*. IV where the Stagirite insists on the complete absence of earth or water from certain homoeomers and on their purity. However, trying to do away with any contradiction between the two sets of passages because presumably the first one centers exclusively on 'theoretical elements' and the second series is concerned only with 'practical elements' seems to me an implausible solution, since it is far from clear that in *GC* II.8 and *Meteor*. IV.4 and 8, in passages that I discussed in connection with the 'official doctrine', Aristotle actually referred strictly to that purely theoretical notion of elements. Therefore, the inconsistency that I pointed out in Aristotle's discussion of pure elements and their separate existence still stands and is likely due to his revision of his own theory and to the fact that, as far as *Meteor*. IV is concerned, it was never polished to a degree that would render it a robustly unified and thoroughly consistent treatise. While I cannot detect any explicit or implicit proof in the Greek text that such a distinction is made in the passages I discussed in connection with the 'official doctrine', that distinction is indeed made *elsewhere* in both *GC* and the *Meteorology* and it raises potentially interesting questions related to my discussion about pure stuffs.

II. What does it mean for a simple body to be truly pure? What are the forms of earth and water and what are the exhalations?

I believe that a comparison between presumably pure stuffs (forms of earth and of water) and the exhalations (in the atmosphere, underground and in materials that have been mined) is a profitable angle from which we can tackle these questions. Elemental transformations are not sudden but gradual, given the continua between the four fundamental opposites.[35] It is possible,

[35] For a discussion about these continua and the notion of *meson* as put to work in the context of the formation of the homoeomers, see Bolzan (1986), 142.

therefore, that this could explain why there are different forms of, say, earth, depending on where they are situated along the continua between cold/dry and cold/moist. It is potentially significant that Aristotle uses expressions like 'forms (or kinds) of water' and 'forms (or kinds) of earth'[36] which seem to echo similar formulations (if not the treatments of this notion) in the *Timaeus*[37] and in several Hippocratic writings,[38] and which seem to indicate that, paradoxically, different stuffs can be made of the same (one) element. That is to say, salt, baked clay, amber etc. are *eidē gēs* in the sense that they are all placed closer to the 'cold' and 'dry' extremes than to the 'hot' and 'moist' extremes, but at somewhat different points along those continua than where Aristotle would place truly simple and pure earth. It is also tempting to think that such stuffs are closer along those continua to 'genuine' (or, rather: 'theoretical') earth than the dry exhalation is, and the same goes for forms of water and the moist exhalation, since Aristotle never refers to the exhalations as *forms* of earth, water etc.

The structure of the sublunary world is represented occasionally in Aristotle and frequently in his commentators as a succession of four contiguous strata, corresponding to the natural places of the so-called elements: earth in the middle, surrounded by water, which in turn is surrounded by a layer of air, the outermost layer being fire, which borders on the innermost celestial sphere and thus on *aithēr*. Given the continuous movement of the heavenly spheres and bodies (especially of the sun along the ecliptic circle) and their effect on the sublunary realm,[39] this model is obviously meant to radically simplify a much more dynamic and wondrously messy structure. Large portions of land rise above waters and the soil contains vast amounts of fire; besides, the simple bodies go through various processes of generation and destruction (most commonly and noticeably in the course of evaporation of

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[36] See 388[a]25–26: *gēs eidē kai… hudatos*; 382[b]11, 13: *hudatos eidē*; 383[b]13–14: *hudatos eidē*.

[37] In the *Timaeus* the *genē* and *eidē* of earth etc. are differentiated according to the variety of the elemental triangles (with respect to their sizes, presumably, not their types) and the blending with other so-called elements in small quantities: 58C5, 58D3, 58D6, 60D, 82A.

[38] E.g., in *On Regimen*: kinds or *genē* of earth, fire etc. are mentioned at IX.3; at X.1 we read about dry and moist water (these examples may refer to compounds, though); at X.3, about the hottest and strongest fire; at XXXII.1, about the lightest water and the most elusive fire; XXXII.2 – the strongest fire, the densest water; XXXII.3 – the thickest water, the lightest fire etc.

[39] On this, see, for example, *Meteor*. I.3 340[b]11–14.

water into air and condensation of air or *atmis* into water, *GC* II.4) that make this model appear all too schematic. The most volatile strata are, expectedly, air and fire, and they are indeed responsible, in Aristotle's meteorology, for a large number of phenomena, ranging from shooting stars and meteors to winds, rain and earthquakes. This picture is further complicated in the first three books of the *Meteorology*, where Aristotle cautions us that 'fire' and 'air' make for a convenient but potentially misleading nomenclature when applied to the stratification of the atmosphere. It turns out that 'fire' and 'air' are the causally unifying principle[40] of virtually all meteorological processes in so far as they are not exactly fire and air, but exhalations that come from the earth when it is exposed to the sun's rays.

I have mentioned before that there are two types of exhalations or *anathumiaseis*, which form the subject of a detailed study in *Meteor*. I–III. (1) There is a relatively cold and moist one, often referred to as *atmis*, which comes about when the water on and in the soil is sufficiently warmed up and which occupies roughly the lower half of the atmosphere or what we take to be air[41] (Aristotle subdivides it into several substrata, depending on the content of humidity and on temperature). (2) The other type of exhalation is brought about when the sun warms up the earth; it is smoky (*kapnōdēs*)[42] and windy (*pneumatōdēs*), hot and dry, eminently combustible, and occupies the upper (or outer) portion of the atmosphere. When these exhalations are enclosed in the earth, the moist one is crucial in the production of metal ore, whereas the dry one is necessary, as efficient and material cause, in the formation of stones. The latter type is sometimes called simply 'exhalation', *anathumiasis* (a term otherwise covering both exhalations) or 'smoke', *kapnos* (a word normally designating only one of the various aspects of this type of dry exhalation).[43] We are told repeatedly[44] that the two exhalations do not

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[40] Regarding his insistence on this unifying principle, see *Meteor*. II.9 $370^{a}26$–33, III.2 $371^{b}18$–20 and III.3 $372^{b}12$–15 (*ho autos epi pantōn harmosei logos*).

[41] In *GC* II, at 2, $330^{b}5$ Aristotle notes that air, being hot and moist, is like vapor (or: a sort of vapor, *hoion atmis gar ho aēr*).

[42] Echoes of this theory are possibly detectable not just in *Meteor*. IV, but also in *PA* II; thus at $649^{a}22$–23, where he submits the hypothesis that the substratum of fire is smoke and charcoal, charcoal becoming cold once the flame has been extinguished, whereas smoke is always hot, 'for smoke is an exhalation.'

[43] Smoke consists of air and earth (*GC* II.4 $331^{b}24$), which are presumably present potentially in the composition of the dry exhalation.

[44] *Meteor*. II.3 $358^{a}21$–22, II.4 $359^{b}32$–34, II.9 $369^{a}13$–15; they are distinguished according to whether they are predominantly, rather than purely, moist or dry.

exist in pure state, a situation strikingly analogous to the simple bodies (see *GC* I.10 and *Meteor*. IV.4 and 8).[45]

To return to my earlier point, although Aristotle uses 'air' (*aēr*) and 'fire' (*pur*) liberally to refer to the two main strata of the atmosphere, he lets us know both implicitly (e.g., through the addition of *hoion* to *pur*: 'quasi-fire') and explicitly that the outer layer is not quite fire and that what appears to be air is not exactly air. Thus, at *Meteor*. I.3 340^{b}20–32 he cautions us that the outermost stratum under the moon is not really fire but a sort of fire (*hoion pur*), since fire as we know it in its common manifestations is an excess of heat and a kind of boiling. What makes this passage potentially confusing is that Aristotle seems to refer to flames (i.e. fire as we experience it here, around the center of the universe) as real fire, despite its apparently being an excessive form of the simple body that envelops the other strata in our sublunary world, whereas the outermost stratum in the sublunary world, whose nature displays a certain balance and appears to be paradigmatic fire, so to speak, is said to be fiery but not exactly fire.

A somewhat similar contrast is offered in *GC* II.3 (at 330^{b}22 ff). Fire (again, as we know it) is an excess of heat, whereas ice is an excess of cold, freezing and boiling being types of excess (*huperbolai*, 330^{b}27).[46] The implication here is likely that the truly simple bodies are somehow more

[45] It is notable that even *aithēr*, at least in the vicinity of the sphere of the moon (see *Meteor*. I.3 340^{b}6–10) and of the dry exhalation, is not as uniformly pure as it might be taken to be in Aristotle.

[46] Theophrastus too raises the issue of a confusion that people tend to indulge in all too readily, namely the confusion between genuine and unmixed elements, on the one hand, and mixtures that we call by convention 'air', 'fire' etc. Theophrastus' remarks (e.g., in the first nine or so sections of his *De Igne*) are more tantalizing than truly promising, as they are not followed up by a concentrated effort to elucidate such confusions, but by vague references to other works or by reminders of the limited scope of the enterprise at hand; one only wishes we still had his treatise on the generation of elements. There are, however, interesting hints at what Theophrastus would have to say on this matter. Fire, according to *De igne*, cannot be an element proper, because its ontological condition is parasitic upon some substrate – earth, water and air (mixed in various ratios, to be sure), but Theophrastus wonders in passing about the possibility of a pure, unmixed fire constituting the Sun and other celestial bodies. While I cannot get into a detailed analysis of that *aporia* here, I should note that Bodnár (2002) comes as close to explaining those very difficult segments (such as sections 4–6) as it seems reasonably possible and contributes substantially to the discussion about potential discrepancies between Theophrastus and the Stagirite, concluding

moderate versions of what we take to be earth, water, air and fire (or rather that the latter are exaggerations of the former). The truly simple bodies are not fire, air etc., but fiery (*puroeides*), airy (*aeroeides*) and so on.[47] Aristotle adds that fire and earth, being at the periphery and at the center of the sublunary sphere respectively, are most pure (*eilikrinestata*), whereas air and water, being positioned between the other two bodies, are more mixed (*memigmena mallon*). That air and water are 'mixed' seems to foreshadow the *Meteor*. I discussion about exhalations, *atmis* – vapor or moist exhalation – being a sort of hybrid, not quite pure water or pure air, except that in *Meteor*. I the outermost layer in the sublunary world is the dry exhalation that is both smoky (that is, earthy) and fiery, which does not fully square with the claim in *GC* about the purity of fire, understood as the stuff that borders on the *aithēr*.

All this may sound more perplexing than illuminating. Still, even if Aristotle's account of the relationship between the simple bodies and the exhalations is fairly turbid, he provides sufficient clues for us to accept that the exhalations are not somehow fundamentally different from the four (sublunary) simple bodies. Let us consider this passage, at *Meteor*. I.3 $340^{b}24$–27:

> But we must understand that the part of what we call air [*tou legomenou aeros*] which immediately surrounds the earth is moist and hot because it is vaporous and contains exhalations from the earth, but that the part above this is hot and dry. For vapor is naturally moist and cold and exhalation hot and dry: and vapor is potentially like water, exhalation like fire [*kai estin atmis men dunamei hoion hudōr, anathumiasis de dunamei hoion pur*].

It is reasonably clear in this context that, while the exhalations are somewhat different from water (and, we should add, air) and from fire, their constitution is still close enough to the aforementioned simple bodies, so that they have the capacity (*dunamis*) to be transformed into them under the right conditions. The moist exhalation becomes water when it is cooled down enough for the vapor to condense into water proper; the dry exhalation becomes fire proper when its disposition to burst into flames is actualized.

Now, what exactly does it mean for, say, the dry exhalation to be close in its constitution to fire without being fire proper? It does not appear to

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plausibly that those discrepancies are not quite the gaping chasm that some make them out to be.

[47] Here I agree with Joachim (1926), 217 and with Williams (1982), 161.

stand quite in the same relationship to fire as, for example, air or earth do in Aristotle's various accounts of elemental transformation; otherwise, he would have called the dry exhalation 'air' or 'fire' or maybe even 'earth', or a combination of these, without much reservation or any qualification. The dry exhalation emanates from the earth when the latter is heated up by the sun; it is 'smoky' (*kapnōdē*, *Meteor*. I.4 341^{b}10) and 'windy' but it is also highly combustible (it is called *hupekkauma* or flammable stuff at I.4 341^{b}19) and the heat produced as a result of the movement of the sun (and, to a smaller degree, of the other heavenly bodies and spheres) easily ignites the dry *anathumiasis* to give rise to presumably sublunary phenomena such as shooting stars, comets and the like (*Meteor*. I.4 341^{b}13–24; cf. I.3 340^{b}12–14).

Olympiodorus' comments on the nature of the exhalations are particularly useful. In an attempt to argue for the continuity between books I–III and book IV of the *Meteorology*, he takes the exhalations to be intermediary (*metaxu*) stages in the mutual transformations of the so-called elements (see, e.g., 16.15–22) or even intermediaries analogous to the so-called elements (at 314.16 ff. he notes that the smoky exhalation corresponds to – *analogei* – earth and the vapor corresponds to water; cf. 319.11–12). At 266.20 ff. he writes that vapor, *atmis*, is in a way water: when condensed, vapor reveals its watery (rather than airy) side; when not condensed, it is water in potentiality, as it is made of finer particles (it is *leptomeresteron*)[48] than actual water (270.29).[49] While this interpretation sounds remarkably sensible (and

[48] Cf. Aristotle's own use of *leptomeres* in *GC* II.2, at 330^{a}2, in a discussion about the emergence of new properties in a compound that comes about as a result of *mixis*. For evidence of a corpuscularian view of matter in early Peripatetic science and philosophy, see Theophrastus' opuscula, especially his *De Igne*, e.g., sections 46 and 49, where the deployment of a quasi-technical terminology including the adjectives *leptomeres* and *mikromeres* (literally, consisting of fine or small parts) seems to underscore his interest in precisely such an approach to the study of matter. I would not exclude the possibility that Theophrastus – who made use of such features somewhat more consistently – might have influenced Aristotle, rather than the other way around, but this can only remain a matter of conjecture.

[49] Olympiodorus seems to imply an unnecessarily corpuscular view of matter in Aristotle's natural philosophy, but this impression of flagrant misinterpretation is mitigated if we consider Aristotle's rather curious references to minuscule masses (*onkoi*). Newman (2006), 13, 28, 65–68 and Chalmers (2009), 65–69 are right to point out the discreet but quite real corpuscularian or granular aspect of Aristotle's theory of matter in *Meteor*. IV, since some of his explanations of

seems supported by the fact that Aristotle presents the constitution of metals and rocks both in terms of exhalations, in *Meteor*. III, and in terms of earth and water or dry and moist, in *Meteor*. IV), given Aristotle's treatment of the exhalations in *Meteor*. I–III, it does not appear reconcilable with Aristotle's own firm objection (*GC* II.5 $332^{a}19$–26) to the possibility that there might be intermediaries between the four sublunary simple bodies.

Accordingly, a plausible answer, I believe, is that the dry exhalation is quite simply earth in the process of becoming fire. In other words, it should be placed in Aristotle's table of elements, so to speak, somewhere close to the 'dry' extreme along the continuum between moist and dry and also somewhere closer to the 'hot' extreme than to the 'cold' one, along the continuum between these two opposites. As for *atmis* or the moist exhalation, it seems to be water in the process of becoming air (or the other way around, as the case may be) and is thus to be placed close to the 'moist' extreme along the dry-moist continuum and maybe rather close to the cold extreme along the cold-hot continuum, but further away from 'theoretical water' than what Aristotle calls the forms of water, *eidē hudatos*.

III. What accounts for the fact that certain uniform stuffs consist, say, just of earth and still have different dispositions?

My inquiry into the nature of the homoeomers has bearing on the emergence of physical dispositions (i.e. dispositions that hinge partly on some particular microstructure) as well. If it is indeed possible, according to Aristotle, that there are different stuffs each made of one element (e.g., salt, baked clay, amber and soda, each consisting only of earth), one may wonder what exactly accounts for the fact that they have different properties (for instance, soda is soluble, baked clay is not, $384^{b}1$–2). Part of the answer lies, I think, in my previous comments: forms of earth and of water may be defined to some extent according to where they are situated along the continua between hot and cold, dry and moist. I would further propose, however, that we should also look for an answer in their 'physical' – rather than merely 'chemical' – constitution. Mostly in ch. 9 we are offered ample and detailed explanations

dispositional properties such as the combustibility of wood are explained in terms of *poroi* or invisible channels of different types (arranged according to different patterns in solid homoeomers), and of particles that can or cannot enter such *poroi*.

of the behavior of uniform stuffs centered on the notion of *poroi*[50] or tiny channels that pervade solid bodies. The microstructure of some stuff (which is among its categorical properties – along with the ratio between its original ingredients, and perhaps the amount and type of heat they contain etc.) can be revealed by some of its dispositions and can implicitly account for those dispositional differentiae. Soda, for instance is thoroughly pervaded by *poroi* ($385^{b}23$) – in a way in which baked clay is not – and this accounts for the fact that soda is easily soluble in water.

It is noteworthy that the exact sequence or progression from primary *dunameis* and elementary stuffs to homoeomers and implicitly to the emergence of secondary or derivative dispositions is sometimes left to the intuition of the reader of *Meteor*. IV, instead of being subjected to keen analysis and overt explanations. In chs. 8–9, for instance, Aristotle describes the (micro)structural characteristics (*poroi* of a certain diameter – allowing water or only fire in etc.), arranged longitudinally or otherwise), which, along with a certain chemical composition (e.g., predominance of earth), explain some of the intrinsic dispositions listed there: fragility, flammability etc. We can safely assume that the *poroi* and the interstices in most solid uniform bodies are caused by thermic reactions, namely by the movements instigated by internal or external heat (whether dry or moist), but exactly how that is supposed to happen is nearly impossible to grasp with confidence for a reader of *Meteor*. IV or is, at best, shrouded in a web of rather opaque hints. Yet, upbraiding Aristotle for the insufficiency of his account could be a rather misdirected exercise. He was certainly aware that his scientific antennae could not possibly help him to provide complete and enlightening proofs for every 'chemical' phenomenon and that he had to strike a balance, precarious though it might have been, between observation and speculation. The thesis that solid bodies are pervaded by invisible *poroi* is never quite demonstrated in *Meteor*. IV, but the apparent *plausibility of the inference* (from the behavior of fragile, splittable, flammable etc. bodies) that they contain such capillaries seems to supplant the need for a more cogent proof. The text of *Meteor*. IV 8 and 9 shows little hesitation in invoking the *poroi* – a layer of explanatory machinery additional to that of the elementary qualities.

[50] On *poroi* (and a possible contradiction with *GC* I.8) and on the issue of authorship, see, e.g., Lewis (1996), 3–9, Viano (2002), 71–72, Pepe (2002), 31–33; for Aristotle's own handling of *poroi*, see *GC* I.9 and *Meteor*. IV (especially ch. 9).

It is likely such a physical organization that could partly explain (together with the position, so to speak, of the forms of earth and water along the dry-moist and hot-cold continua) why different stuffs such as clay, soda, salt etc., while consisting of only one element, can nonetheless exhibit different qualities. It is a further question whether this might also explain why, say earthenware or a lump of salt preserve their internal cohesion despite their complete loss of water and, by the way, against the precepts put forth both in *GC* II.8 and in *Meteor*. IV.4 and 10.[51]

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