

## **Mixing the Elements**

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All bodies in the sublunary world are composed of mixtures of all the primary elements – fire, air, earth, and water. Aristotle argues for the primacy of these four elements in the constitution of objects in our world. He further develops an original theory of mixing of elements to explain the formation of uniform matter such as granite, flesh, or oil. His theory of mixing of elements has received much attention in the past decade, resulting in an exciting array of interpretations that have also generated contributions to contemporary philosophy. In what follows I offer an account of Aristotle's theory of elements and their mixtures, and survey the main alternative readings of his position.

### **The Elements**

Aristotle sets out to explain the constitution of things in the world through the process of their generation and corruption. He bases his ontological investigation on the very foundations of the cosmological edifice, the elements: 'an element ... is a body into which other bodies may be analysed' (*De Caelo*, 302a15-16). If there is to be generation in the world, there needs to be more than one element; for otherwise, every thing would be that element in merely altered states (*Generation and Corruption*, 332a6-9). Change is to contraries (e.g. from being hot to being cold, *GC* 332a7-8); but contraries do not change into

each other (e.g. it is not the hot which becomes cold, but the hot body, 329b1-2); nor do contraries underlie each other as matter (e.g. the hot does not constitute the cold, 329a32-33); rather, a third thing, the matter, underlies the contraries and remains through the change (332a7-18). The matter is inseparable from the contraries, and with them constitutes the elements (329a24-27).

Aristotle explores which contraries are the primary ones for the constitution of tangible bodies by considering several candidate pairs of contraries. He engages in a characterisation of the various contraries such as viscosity, softness, hardness, liquidity, solidity, etc., in terms of their functional properties, on the basis of which he concludes that some are derivable from others: 'all other differentiae are reducible to these four primary ones, whereas these cannot further be reduced to any smaller number' (330a24-26). The four primary contraries are the hot, the cold, the wet and the dry (329b25-31).

On the basis of the four contrary qualities, Aristotle derives that their combinations result in there being four elements or primary bodies: 'fire is hot and dry, air hot and wet (for air is something like steam), water cold and wet, and earth cold and dry' (330b3-5). The four elements have natural places in the sublunary world, and a natural movement by which they get there: 'fire and air belong to that which moves towards the boundary, earth and water to that which moves towards the middle' (330b32-33). In *De Caelo* he explains that earth is absolutely heavy, and moves naturally downwards towards the centre of the universe, if not impeded, while fire is absolutely light, and moves naturally upwards. Air and water combine these properties and are intermediate, 'since while they rise to the surface of some bodies they sink to the bottom of others' (311a23-24). Their natural movement is explained in terms of their lightness and heaviness: 'that which produces upward and downward movement is

that which produces weight and lightness' (310a31-32). Since, as we have seen in *Generation and Corruption*, all other differentia of bodies are reducible to the four primary ones, 'that which produces' the movement and the weight and the lightness is to be traced to the primary contraries.

The notion of being absolutely light and absolutely heavy in *De Caelo* is an indication of the way Aristotle understands the four primary contrary qualities. The hot, for example, in fire and air, is absolute heat, and the wet in water and air is absolute wetness. So understood, the four primary qualities in *Generation and Corruption* are in fact contradictories, as Williams also observes, rather than contraries.<sup>1</sup> But combinations of the primary elements produces material that possesses the contraries to various degrees.

Aristotle considers various alternative models for the generation of the primary elements, and concludes that their generation is reciprocal from one another. What makes this possible is their composition in terms of pairs of contraries which the matter of each element can lose or gain. Thus 'from fire there will be air if one of its properties changes, the former having been hot and dry whilst the latter is hot and wet, so that if the dryness is conquered by wetness there will be air. Again from air there will be water if the heat is conquered by cold, the former having been hot and wet, the latter cold and wet, so that if the heat changes there will be water' and so on. (331a26-32) No element has any type of priority over the others with respect to generation and corruption.

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<sup>1</sup> C.J.F. Williams, *Aristotle's De Generatione et Corruptione*, Clarendon Aristotle Series ed. J.L. Ackrill, Clarendon Press, Oxford, 1982.

## Combining the Elements

Every object that is not uniform is composed of uniform stuff (321b18-19). Nonuniform objects are those whose parts are of a different type than the whole, e.g. a tree, a house or an animal. The leaves of the tree are not roots, nor are they composed of wood, and the finger of an animal is not a tooth, nor composed of the same stuff as it. But the stuff that nonuniform objects are composed of *is* uniform, e.g. flesh and bone for the finger, and wood and soft tissue for the tree. Uniform stuff is the material of the world around us. It is therefore significant for Aristotle's investigation of nature that an account be given of the generation of uniform matter. As we would expect, and as we shall see, there is an intimate connection between the primary elements and uniform matter. All uniform matter is composed of all four of the elements; it is generated by a process that Aristotle calls mixing. What is metaphysically significant is that mixing is different from, and does not involve, substantial composition, although a new entity is created through mixing. Understanding Aristotle's account of this alternative metaphysical phenomenon of generation is our task in what follows.

We can hardly improve on Aristotle's introduction to the problem of mixing. He begins with a puzzle he inherited (327a33-b6): there are three possibilities, presumed exhaustive, of an account of mixing, none of which delivers the phenomenon. First, if the things that have been mixed still persist unaltered in the mixture, then they have not been mixed since they remain the same as they were before they entered the mixture. Secondly, if either of the original ingredients is destroyed in the process of mixing, then they are not mixed since there is only one remaining, while in a mixture the ingredients are in the same condition. Thirdly,

it follows that there is no mixing if both ingredients are destroyed in the process, since they cannot be in the state of being mixed in the mixture if they are not at all (*holōs ouk onta*).

It may appear that the outlined possibilities suffer from a rather obvious lacuna, namely that the first option can be subdivided into two: they both persist unaltered, or they persist altered. But this would not affect the puzzle. If both ingredients persist in the mixture, each of them in an altered state, since they could have been found in that same state independently of being mixed, there is no reason to suppose they are mixed; there is nothing that marks off their state as mixed rather than unmixed. This presupposes that for an ingredient to be mixed with another is not for them to come to some external relation that respects their claim to persistence. Such relations between items abound without the items thereby becoming mixed with each other. In general, we need to assume that for the puzzle to have a bite, no way in which the ingredients can be when unmixed will explain how they are in a mixture, since they can be that way unmixed. That this is what Aristotle has in mind is confirmed by the fact that he takes this puzzle to invite us to differentiate between mixing on the one hand, and generation and corruption on the other (327b6-9); the qualification of the first horn that they persist *unaltered* plays no role in the dilemma; the relevant factors in the reasoning are only persistence and corruption, not alteration.

So we have learned that mixing cannot be explained in terms of the ingredients persisting or ceasing to be. But before offering his explanation of mixing, Aristotle introduces a further condition: ‘when two things are mixed each must exist as a separable thing’ (327b21-22). A thing is not mixed with its affections, or its dispositions, since neither affections nor dispositions ever exist separately without belonging to some subject. What is initially surprising is that Aristotle invokes this separateness condition for mixing to exclude these

cases, although he has just achieved the same effect on the basis of the conditions of the initial puzzle. He has just pointed out that affections and dispositions cannot be mixed with the things that have them because they are preserved (327b15-17, b29-30). So these cases are already blocked by the first horn of the dilemma. If something persists, whether it enjoys an independent or a dependent existence, it cannot be in a state of being mixed while persisting. Affections and dispositions persist when they come to be possessed by a substance; when a body becomes white: ‘both remain in actuality ... the body and its whiteness’ (327b29-30). Why then introduce the separateness condition since persistence suffices? There may be more than one motivation, but what I take to be crucial in this clarification is that *ontological dependence* itself is different from mixing. This is of particular importance for the explanation Aristotle gives of mixing (in the very same passage, 327b22-26), which makes use of the notion of *potential existence*. It is not ontological dependence that is at the root of mixtures, because ontological dependence does not undermine the *actuality* of the dependents, as we just saw with the body and its whiteness; whereas *mixing must undermine the actuality of the ingredients*, if we are to escape the dilemma above.

Since the ingredients cannot cease to be nor persist in a mixture, not only alteration but transformation, too, namely generation or corruption, is different from mixing. When wood burns, it is not being mixed with fire. Rather, it ceases to be and fire is generated (327b10-13). Growth is not mixing either, because one component persists, the growing one, and the other ceases to be, the nourishment (321a34-35, 322a11-13).<sup>2</sup>

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<sup>2</sup> The phenomenon of growth is different from that of generation too. In growth, as in alteration, the object that grows persists in actuality and survives the change, but becomes altered; each part of it becomes larger due to another thing which accedes to it (321a19-22). The thing that accedes does not survive because its substance is destroyed (321a34) when it is assimilated in the growing object.

## **Mixing by Division**

Aristotle considers the mechanism of mixing by division as the main candidate for explaining the survival of the original ingredients in the mixture, and their recoverability; division generates small parcels of matter, preserving the kind and the parts of the original ingredients. The first account of mixing Aristotle considers is one where the parcels are so small that it is not possible to discern the parcels of one of the ingredients in the mixture from the parcels of the other ingredient (327b32-35) – I will assume, with Aristotle, that there are two ingredients only, for simplicity. I agree with Williams (p. 146) that it is not necessary, in this first account, that the parcels of stuff are alternating between the two kinds. All that the present conception of mixture requires is that they be small enough for their difference in kind to be imperceptible, whether they are clustered together in small groups per kind or not. He immediately abandons this possibility, and the reasons why can be discerned from the conditions that characterise mixtures, which we gradually encounter in what follows.

There are three reasons that speak against mixtures modulo perception. The first and most important condition is that mixtures, according to Aristotle, are homoeomerous - uniform. At first glance, mixtures modulo perception appear uniform, which might suggest that they satisfy the uniformity requirement. But Aristotle tell us what he means by uniformity, which is a much more stringent requirement than uniformity in appearance: ‘just as a part of water is water so it is with what has been mingled’ (328a11-12); so a part of a mixture must be the same kind of stuff as the whole mixture. Clearly what looks uniform but consists of parcels of matter of two different kinds does not satisfy the criterion for being a homoeomer. Even if

the whole is taken to be a ratio of the two different kinds of stuff, small enough parts of the whole will consist of one only kind of stuff.

The second reason against mixtures modulo perception is that the resulting whole is not a mixture but a composition of parts. This objection too is premised on the uniformity of mixtures. Since every part of a mixture is the same kind as every other part of it, mixtures are not compositions of parts that are different in kind in the way that salt and pepper, when intermingled, are. Finally, the third reason is the relativity of perception. Aristotle says that “‘being mixed’ would be relative to perception: one and the same thing will be mixed for one man whose sight is not sharp, whereas for Lynceus nothing is mixed” (328a13-15). Williams thinks that the relativity of perception is a defeasible objection to mixing modulo perception, since there comes a point of smallness of parcels of matter which makes them indiscernible to human sight (p. 146). So even Lynceus would not be able to tell that the mixture is not uniform. But there is no in principle impossibility of (technologically aided) discernability, which suffices for the objection to stand.

Aristotle’s second attempt at mixing by division is far more sophisticated and complex. We are again considering the division of the ingredients into small parcels (*eis mikra*) but now, they must be, not small enough to be indiscernible to perception, but small enough to be ‘arranged in such a way that every single part of either of the things mixed is alongside some part of the other’ (328a1-2). For example, consider salt and pepper so arranged. Aristotle examines whether such an explanation will satisfy two conditions for mixing. The one is that every body, including mixtures, is divisible, but not thoroughly divided, which is an Aristotelian metaphysical tenet. The second is that a mixture is uniform. To show that the present account of mixture satisfies uniformity, he considers a second conception of

uniformity (after the abandoned ‘uniformity in appearance’), which is that ‘every part of one [ingredient] would have to come to be alongside some part of the other’ (328a5). At first glance, salt and pepper could satisfy this homoeomerity requirement if properly arranged. But the impossibility of thorough division blocks this possibility. For a successful adjacency arrangement it would be necessary that each ingredient was divided into the smallest possible parts, which would then be arranged side by side, ensuring that no two parts of a single ingredient were adjacent. But since every body is divisible, but not thoroughly divided, every part of each of the ingredients will be divisible, and there will be no smallest parts (328a5-6). Hence, uniformity cannot be satisfied even on its second conception of adjacency of parts. And the final blow is struck by Aristotle pointing out that even if it were satisfied, still this would not be a mixture because this conception of uniformity is not the appropriate one for mixtures. Adjacency is a type of composition, not mixing, which requires a different kind of uniformity than composition.

Williams thinks that Aristotle fails to make his case against mixing being composition (pp. 146-148). He argues that the reasoning we just rehearsed is valid only if Aristotle was attacking some form of Atomism, as most commentators assume. But if the smallest parts are not assumed to be atoms, but infinitesimals, then further possibilities arise (pp. 146-147). Williams begins by challenging the logic of the following sentence:

But if every body is divisible, given that a body mixed with another is homoeomerous, every part of one would have to come to be alongside some part of the other. (328a3-5)

Williams finds the sentence inconsistent on the Atomist reading of this argument. If there is infinite divisibility, then there are no atoms, and hence uniformity *qua* adjacency of atoms

would be impossible; yet exactly the opposite seems to be suggested in Aristotle's sentence above, which turns it into nonsense. In consequence, Williams suggests that possibly Aristotle is here entertaining an account of mixing based on a theory of infinitesimals (pp. 147-148), not atoms. According to it, 'every (infinitesimal) part of *B* would have to get alongside some part of *C* and vice versa. Homoeomerous mixture = alternation of infinitesimal parts' (p. 147, where *B* and *C* are the ingredients of the mixture). According to Williams, this is the only way to make sense of Aristotle's quoted sentence above, and not through the traditional Atomist reading of it. Furthermore, Williams wonders whether Aristotle's 'rough rejection of it [is] a sign that he has not fully grasped its significance, that he has perhaps confused it with an Atomist theory of indivisible *minima*' (p. 148). Aristotle's rejection of it is based on his claim that 'there is no such thing as a thing's being divided into parts which are the smallest possible' (328a5-6).

Has Aristotle missed out on a possible explanation of mixing? Williams does not explain how this reading might help us make sense of Aristotle's sentence above, other than to say that we should think of infinite division resulting, not in atoms, but in limits or infinitesimals. Let us pursue this interpretation. Consider a mixture where the ingredients divide each other infinitely; there is total interpenetration. We could think of two lines, a red and a green one, merging into one line. Take the case of infinitesimals first, i.e. the points in the lines. The lines would be thoroughly mixed after their merger, in the sense that given any two points of one of the lines there would always be a point of the other line in between them. This would indeed satisfy the thorough divisibility and mixture requirements, as well as the conception of uniformity given in the sentence above as systematic juxtaposition (328a3-5). The case of limits may be of even greater interest. Let us suppose the merger results in a line, every point of which is a limit for each of the two lines. I mean the following: every point in the merger

is a point where each of the two lines meet – it is an end point, as it were, of each of the two lines, at which the two lines touch. Then we can think of each point as being the limit at which each of the two lines converges. In that sense, each of the two lines is present at each point! Could it be that such an account of mixing would satisfy, not the systematic juxtaposition requirement any more, but indeed the Aristotelian conception of uniformity, where every part of the mixture is of the same kind as the mixture (as in water)?

There are several reasons why Aristotle would not be satisfied either with the infinitesimals or with the limits conception of mixing. First, for Aristotle there is no thorough interpenetration, because no infinite process, such as the infinite division of bodies, can be actualised (328a5-6). Further, the solution in terms of the infinitesimals or the limits requires that the lines be composed of them, which introduces the problem of the dimensionless making up an entity with dimensions points or limits cannot be *parts* of a line, whereas the division of a body for Aristotle is division into parts; when does this division cease to separate parts and isolates entities without dimension? Furthermore, at least on the account with infinitesimals, we still have mere composition, whereas Aristotle distinguishes mixing from composition (328a6-7); the components of such composition are either of the one or the other kind of stuff, hence it is not a proper Aristotelian homoeomer (like water). Finally, on either the infinitesimals or the limits account, we cannot explain how mixtures can have different proportions of ingredients (e.g. 2:3 parts respectively).

So Aristotle is neither confused, nor does he fail to fully grasp the significance of the suggestion made at 328a3-5. Even more importantly, this sentence is not inconsistent. Williams is wrong to accuse Aristotle of all these failings, because as we saw, infinitesimals do not provide an answer towards an account of mixing. How then are we to understand

328a3-5? It introduces mixing by division into parts. Even with every body being divisible, for Aristotle the end points of such division processes are not infinitesimals, since infinite processes are not actual. The end points of divisions would not even be atoms, since 'there is no such thing as a thing's being divided into parts which are the smallest possible' (328a5-6). So division produces only small particles. Furthermore, it is clear that for the purposes of the mixing by division hypothesis, Aristotle is introducing the term 'homoeomer' in an everyday way of understanding it, namely as uniform juxtaposition, e.g. as it would apply to the sand on the beach which is homoeomerous: grains of different types of stone are intermingled with one another uniformly. This is clear from the stringent requirement of thorough juxtaposition in 328a3-5: given (*eiper*) that mixed bodies are uniform, every part of one would have (*deoi an*) to come to be alongside some part of the other. This explanation of a homoeomer is of course incompatible with Aristotle's understanding of it (as it applies to water), but he is countenancing it here to present his reasons against mixture by division, which he does in the lines that follow. Such an intermingling of parts would be a composition, not a mixture; it would not be a proper homoeomer (like water), since it would have parts whose kind would be different from that of the whole (e.g. being just salt, or just pepper); and finally, it would not be uniform even in the juxtaposition sense, because due to divisibility, some parts of each of the intermingled ingredients would always be adjacent to, or contained in, parts of the same ingredient (328a5-16). This completes Aristotle's criticism of mixing by division.

### **The Account of Mixing and Potential Persistence**

Aristotle seeks the solution to the puzzle of mixing in the distinction between the ingredients surviving in potentiality, and their surviving in actuality. He is concerned to distinguish

mixing of substances from the generation and destruction of substances on the one hand, and from the growth of substances on the other. In so doing, he generates a new metaphysical theory which accounts for the uniformity of the kind of the stuff that substances are made of, e.g. of blood or of bark. I will first present in outline Aristotle's theory of mixing, and then examine how successfully his theory addresses the challenges it faces.

*To be and not to be*; that is the challenge. Aristotle says it is possible for the ingredients of the mixture to be and not to be in the mixture:

Since some things that are, are potential, and some actual, it is possible for things after they have been mixed in some way *to be and not to be*. Some other thing which comes to be [*gegonos*] from them is actually [i.e. the mixture], while each of the things which were, before they were mixed, *still is*, but *potentially*, and has not been destroyed [*ouk apolōlota*]. This is the solution to the problem raised by the previous argument. (327b23-26, my emphasis.)

In this initial statement of the solution, we find the first of the two principles of the Aristotelian account of mixing regarding the fate of the ingredients in the process of mixing – they are not destroyed, but survive in potentiality. This is qualified by a further claim, which is related to the first but regards the fate of the ingredients post-mixture:

Things that are mixed manifestly come together from having formerly been separate, and are capable of *being separated again* [*chōrizesthai palin*]. (327b27-29, my emphasis)

The second principle is the requirement we encountered in the discussion of mixtures modulo perception about the nature of the new thing which comes to be, namely the mixture itself:

a body mixed with another is homoeomerous ...

... we say that if things have in fact been mixed the mixture has to be homoeomerous, and that just as a part of water is water so it is with what has been mingled. (328a4-12)

We can thus summarise the Principles of Mixing on which Aristotle's solution is based as follows:

PM1 *Survival*: The ingredients that are mixed survive in the mixture in potentiality, not in actuality, and can be separated again.

PM2 *Uniformity*: The parts of a mixture are of the same kind as the whole mixture.

There are issues to examine, question, and explain in relation to the two principles. We shall be aided by Aristotle's discussion of the ways in which mixing differs from other phenomena, and his examination of borderline cases of mixing.

Survival in the mixture is explained in terms of potentiality, but the latter notion is broad enough to allow for a variety of types of survival. To understand the type of potentiality at work in PM1, we need to determine the sense in which Aristotle claims the ingredients to still be in the mixture. We saw in 327b23-26 above that the ingredients that go into a

mixture in some way are even after they have been mixed; they are potentially the things *they were* before the mixture; and they *have not been destroyed*. But they also are not, because some other thing has come to be from them as ingredients. The sense in which they are not is given by an example Aristotle offers to contrast the survival of the ingredients with survival in accidental unities such as of the body and its whiteness. The first difference is that the ingredients that go into a mixture are not ontologically dependent entities in the way that an affection is, e.g. the whiteness of a body: ‘When two things are mixed each must exist as a separable thing, and no affection is separable’ (327b22-23). The second difference is that ‘neither do they both remain in actuality like the body and its whiteness, nor do they perish – either of them or both – because their potentiality is preserved’ (327b29-31). A body remains that very same body in actuality when it becomes white, and whiteness is in actuality when it qualifies the body.

The ontological dependence of whiteness on the body does not threaten its actuality, which consists in being the specific type of pale that white is. But if the ingredients of a mixture remained in actuality, their actuality would involve actuality of form, and of ontological separateness, not only separability. But we already know that Aristotle said in 327b22-23 that the things that are mixed remain only separable. Therefore, they are neither separate, ontologically independent, nor therefore could they retain their form in actuality, as whiteness does, since they are essentially the type of entity that is separate. Another thing comes to be from them, and they become ontologically dependent on it while mixed, as its components. But they do not get composed into this new thing in the way that the parts of a substance are composed into the substance as a whole. They do not become reidentified by being enformed by the substantial form of the new entity. The impact on their nature of their demotion to ingredients in the mixture is of a different type than the assimilation of

components into a new substance. We shall turn to the type of change suffered by their nature in what follows.

Separability, which Aristotle insists on for the ingredients in a mixture, is a fundamental requirement which characterises mixing as a distinct type of process. It distinguishes mixing from the generation of a substance by specifying how the ingredients survive in the mixture; they are recoverable, while what is transformed in a generation is not recoverable. But more importantly, it gives us a criterion for the potentiality of the ingredients in a mixture, which distinguishes this potentiality from other types of it. The criterion is that the ingredients in a mixture retain whatever their numerical recovery requires. They do not survive in the mixture, for then the mixture would be their mere alteration, which we found dismissed in the initial puzzle. But the recovery will be a recovery of things numerically identical to the initial ingredients, not of things like these ingredients.<sup>3</sup>

What is required to retain the potentiality for the recovery of the numerically identical entities? Aristotle does not offer the answer to this question, but a solution can be found to fit the framework of his account of mixing. In order to address this question we need to examine the second Principle of Mixing, Uniformity.

Uniformity, or homoeomerity, has figured in the preliminary discussion of mixing we examined in the above, in different senses, but finally as the requirement that a part of a mixture be the same type of stuff as the whole, as it is with water. What we have not encountered so far is the mechanism through which different ingredients together manage

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<sup>3</sup> Despite Aristotle's explicit assertion of the recoverability of the ingredients that go into a mixture, there are cases where the ingredients are recoverable in principle only. For example, consider mixing some hot and cold water. **It will appear in what follows why I believe that even in such a case they are recoverable in principle.**

this feat, namely to produce a thing that is a single type of stuff, uniformly throughout.

Aristotle describes this mechanism as follows:

when the two are more or less equal in strength, then each changes from its own nature in the direction of the dominant one, though it does not become the other but something in between and common to both. (328a28-31)

Consider mixing two ingredients that can affect one another, e.g. honey and wine. The honey becomes less viscous and more watery or wet, due to the effect of the wine on it, and more sour, while the wine becomes thicker, less watery, and sweeter due to the effect of the honey on it. The causal interaction reaches equilibrium at some point, when neither the wine nor the honey, in their new tempered state, overtop the other in being watery, or acidic, or viscous or sweet. Both are equally viscous or acidic, etc. Thus the effect of each on the other stabilises. But it does not stop, because then each of the two would revert to its own nature of being more liquidy and sour, or more viscous and sweet.

It is fundamental to understanding Aristotle's explanation of mixing that we recognise that the *essential nature* of each of the ingredients of the mixture is changed, compromised. Their natures are not destroyed, because that would result in their corruption and the generation of new substances. Although their natures are not destroyed, they are altered, though not irrecoverably, since that would be destruction and the generation of a new type of substance. Their natures are altered under the causal influence of each on the other ingredient, while that influence lasts. We should think of the natures of each of the ingredients in a mixture as a compressed spring, which remains so while the force is exerted upon it, but is ready to recover its full length when released from the force exerted upon it. If

we think of two springs pressing against each other until their powers equalise, we begin to see how the nature of each ingredient in a mixture imposes itself on the other, bringing about changes until their respective natures are compromised to the point of not being able to affect the other more in any way. They keep each other at this compromised state of tension and strength equilibrium by continuously affecting each other and checking each other's nature for any kind of superiority in causal efficacy. The result is a type of mutual normalising of natures.

We are now in the position to address the question of the First Principle of how the ingredients retain the potentiality for numerical identity. The one factor is the inevitable fate of each ingredient in the mixture: it is altered by the other ingredient until the causal powers of their contrarities are equalised; the other factor is that each ingredient must retain the potentiality to recover, or revert to, the object it was before entering the mixture. If these two factors cooperate when we mix, the result is a mixture; if not, the result is either compresence of different (unmixed) materials, or destruction of one or both of them. Therefore, however the potentiality of an ingredient to be the object it was is retained, this must not impede the causal equalising of contrarities in the ingredients. Aristotle requires that 'each changes from its own nature [*phusis*] in the direction of the dominant one, though it does not become the other but something in between and common to both [*koinon*]' (328a30-31). By 'dominant' Aristotle means any type of causal strength that each of the ingredients has on the nature of the other. What is common to both is the compromised state of each ingredient's nature which equalises them in causal efficacy. This means that neither is superior to the other in respect of any contrariety, such as hot or cold or wet or dry, or their derivatives, which are the characteristics that determine the nature of each ingredient. So the compromised natures are equal in wetness and heat, dryness and cold, etc.

That the ingredients should be ‘more or less equal in strength’ (328a29) is also a tacit reference to the relative quantity of each ingredient. Aristotle has said in just the previous sentence that when there is gross inequality of quantity between the two ingredients, then it is not possible for their opposite characteristics to keep each other balanced, but the one is overpowered by the other. Going back to our springs example, a small spring would be crushed by a very powerful one, not just compressed. Aristotle’s example is the following:

when many of them are juxtaposed to few or large ones to small, then indeed they do not give rise to mixing, but to growth<sup>4</sup> on the part of that which is dominant; for the other changes into the dominant one: thus a drop of wine is not mixed with ten thousand pitchersful of water, for its form dissolves and it changes into the totality of the water. (328a24-28)

The nature of the drop of wine is destroyed by the causal effect of the large quantity of water around it. It is as if there were an inexhaustible source of opposite characteristics to those of the small quantity of wine, overwhelming the wine’s characteristics until even their source is obliterated, leaving no trace of the wine’s nature behind. Quantity plays a role in the outcome, as *causal strength* is measured in quantity as well as intensity of opposites. Thus extremely hot lava mixing with lukewarm mercury could result in equalising of temperatures, if there was plenty of lukewarm mercury around it. But high intensity and large quantity are devastating; a drop of mercury in an erupting volcano would be destroyed.

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<sup>4</sup> See note 2 above.

So here is the metaphysical picture of mixtures so far: each ingredient in a mixture is changed in its essential nature, by having its characteristics compromised due to the causal interaction with the other ingredient. The nature of each ingredient is not obliterated by the causal interaction, but altered, so that it is not any more the type of material that it was before entering the mixture; what it is missing are the characteristics which are necessary for this type of thing, but which are now compromised. Although the ingredient does not possess these characteristics while in the mixture, it has not lost the power to restore them, if released from the causal interaction with the other ingredient.

But what does the restoration of the nature of each ingredient involve? On what is the *potentiality* for this restoration grounded? It is grounded on the only factor in which the *nature* of an ingredient could be anchored, namely, the *enformed matter* of that ingredient. The enformed matter is what constitutes the ingredient before entering the mixture. In the mixture, the matter of each ingredient is still enformed, but the form is altered, compromised by the causal effect of the other ingredient. The matter of each ingredient is divided up into small parcels in the mixture, as we shall see in what follows. But each part, say of honey, retains the potentiality to regain its original form when the causal influence is withdrawn.

To see how it is possible to retain the potentiality even for a complex form, we can consider an example, which is not a case of mixing. If we have a vase which we break up into small pieces, the form of the vase is retained in potentiality in the pieces, and can be restored if the pieces are glued together again. There is no vase once it is broken up into pieces, but it has not been destroyed in the sense that it can be restored. When restored, it is numerically the same vase as it was before it was broken up. Now consider two vases which crush onto each other. The tiny pieces from each vase become mixed up in the resulting rubble. But both,

the forms of the vases and the vases themselves can be restored. But achieving the latter requires more than restoration of shape; to restore numerically identical vases we need to select out the pieces of each vase. To see why, consider two identical vases which we cut up into tiny square pieces each, and then mix up the pieces. It is possible to restore two vases by putting the appropriately shaped pieces together, paying no attention to the origin of the pieces but only to their shape. Then we would have two new vases which would be identical in form to the original ones, but not numerically identical to either of the original ones. The numerical identity of the original and the restored vases requires restoring the same form and matter of each vase. The sameness of matter secures physical continuity and brings with it the historical features of the form of each vase.<sup>5</sup>

The same analysis applies to mixtures, too. The matter of each ingredient in a mixture is divided up into small pieces which interact with the pieces of the other ingredient, compromising the form of each other. But when each piece of each ingredient is not being affected by the other ingredient, then its form is restored; and when the pieces of the each ingredient are put together again, then each ingredient is restored. Each ingredient is restored because the original quantity of matter regains the same form, e.g. of honey or wine, as it had before entering the mixture. The same type of complexity that we encountered in the case of the vases can be encountered here too, e.g. by mixing two similar wines together. But their similarity does not change the metaphysics of the mixture. The same analysis of potentiality of forms and of ingredients remains, even if restoration is possible only in principle.

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<sup>5</sup> Finally, if the two vases are pulverised and then mixed up, it may be only in principle possible to restore them again, but not in practice. The potentiality for the form and each vase to be restored would remain, but we may not be able to bring it about.

Aristotle's account of mixing applies to mixtures where the ingredients affect each other's nature. If the ingredients affect each other's *accidental properties*, then restoration of accidental features cannot be secured, although separation of ingredients is possible at least in principle. For example consider mixing hot and cold water. The quantities mixed will give rise to lukewarm water; they can even, in principle, be separated out again. But their original temperatures will not be restored to each of the ingredients by the separation. The reason is that the potentiality of form is not preserved, because there is no anchoring of the accidental features onto any particular matter; the original heat of each quantity of water is not tied to that quantity of water but to its previous environment. This contrasts with the case of the compromise of the nature of each ingredient; here the form of each ingredient is anchored onto the enformed matter of the ingredient; honey is sweet unless, and while, under the influence of e.g. wine.

The formal and the historical continuity between the ingredient before entering, and after it enters the mixture is what distinguishes mixing from generation. In generation, although the same quantity of matter remains, it loses the form of the original object, and with it the historical continuity with that object, which is why that object cannot be restored. Even if the same form is repeated, as it could in a metal statue, the causal history of that form anchors it in the new, post destruction, environment, not in the matter/nature of the original statue. By contrast, the parcels of the enformed (but compromised) matter of an ingredient in a mixture are the seat of the physical, formal, and historical continuity with the original ingredient. They possess the potentialities for the restoration of the form and also the ingredient. In some cases, restoration may be physically possible, as in the case of salt and water. But in other cases it will be only in principle possible, as in the case of water and wine. Even in this

case, the parcels of matter of the ingredients carry the potentialities for restoration, but separating them out from the mingled state they are in the mixture would be a physical feat.

This is what a mixture is for Aristotle. The ingredients that enter the mixture causally affect each other until their powers of contrarities are equalised. This process deforms each of them, equalising their contrarities, and keeps them in that common state while their causal effect on each other lasts. In that state, the matter of each ingredient is still informed by the nature of each ingredient, but the nature is compromised due to the causal effect of the other ingredient (328a28-31).

Uniformity is thereby achieved. Every part of the mixture is equipotent with every other part of the mixture. None is warmer or sweeter or drier than other parts of the mixture. Some of these parts are parts of the first ingredient, some of the second, and some of both; but their form in the mixture is the same, being checked for excess or deficiency by the causal powers of each on the other. At the same time, each part of the mixture carries potentialities and continuities which are *not* shared by every other part of the mixture or by the whole. These are the ground for the possibility of the restoration of each ingredient after having been mixed.

### **Further Considerations on the Mechanism of Mixing**

In the above I have assumed that each ingredient is cut up into small pieces while in the mixture. This follows from Aristotle's account of causal interaction between ingredients, to which I will now turn. Causal interaction smoothes out differences in contrarities: 'what is

active makes the patient like itself. For agent and patient are contraries, and coming to be is to the contrary. So it is necessary that the patient change into the agent ...' (324a10-13); 'of agents, those are capable of being mixed which have a contrariety (for it is these which are capable of being acted upon by one another)' (328a31-33). Thus the ingredients of a mixture change each other into something that is common to both, since both act as agents and as patients until they equalise their contrarities.

The way that causation is engendered is by the *contact* between the agent and the patient:

“for neither is acting and being affected possible in the strict sense for things which cannot be in contact with each other, nor can things be mixed unless they have first had some sort of contact. ... It is necessary for those things which are involved in mixing to be capable of contact with one another, and the same holds for anything which properly speaking acts on, or is affected by, another.” (322b22-29)

Contact is a necessary condition for the agent to affect the patient. Thus the ingredients of a mixture need to be in contact with one another in order to affect each other. But contact by itself may not be sufficient for mixing to take place. Further conditions need to obtain to expedite mixing.

To understand the complexity of the mechanism of causation it would be helpful to consider how fire warms up the water in a pot. Fire warms up the pot by coming in contact with it. But fire does not come in contact with the water in the pot, although it manages to warm it up as well. This is achieved by fire warming up the pot, which is in contact with the water, and thereby warms up the water. The end result is that the heating effect of the fire extends to

some distance from the point of contact between it and the pot. I will call this distance between the point of (agent-patient) contact and the furthest point in the patient which is affected by the agent the *causal range* of the agent on the patient.

Aristotle does not talk of the causal range of an agent on a patient, but it follows from his description of what expedites mixing. He says:

amongst things which are divisible and capable of being affected those which are easily bounded are capable of being mixed, since they divide easily into small parts ... For instance, liquids are the type of bodies most liable to mixing, for liquids are the most easily bounded of divisible things, unless they are viscous. (328a35-b4)

We can explain why those bodies which are divisible and easily bounded are most of all capable of being mixed. Being most easily bounded maximises contact between agent and patient. Secondly, being divisible into small parts makes possible the causal effect of the agent to reach all the parts of the patient. Thus 'small quantities put alongside small quantities mix better, because they change one another more easily and quickly' (328a33-34). The contact area increases and the distance which the effect has to reach decreases. Things which do not divide up easily resist mixing with whatever they are brought into contact: 'liquids are ... most liable to mixing ... unless they are viscous (these have the effect only of multiplying and increasing bulk)' (328b3-5).

It therefore follows that for Aristotle, each of the ingredients of a mixture is divided into small parts and is in contact with the parts of the other ingredient. But the parts are not infinitesimal. We already saw that Aristotle does not believe that a division could be carried

to completion (328a5-6). In fact, the division need be such as to allow each part of each ingredient, acting as agents, to causally affect through and through each part of the other ingredient acting as patient. The causal range of the causal efficacy of each ingredient will place an upper limit on how large the pieces can be in the mixture before mixing stops being possible. But if the parts into which each ingredient is divided are not too large for their causal range, the intermingling of parts of the ingredients will suffice to allow the causal equilibrium to be reached, reducing the ingredients to the common state that is the uniform nature of the mixture.

Thus, the common form of the mixture is *not* a *ratio* between ingredients. It is not that e.g. there are two parts of the one and three parts of the other ingredient in every part of the mixture we consider. On Aristotle's account, it may be that a part of the mixture derives fully from one only ingredient. But what makes the mixture uniform is that the form of that part of the mixture is the same as the form of a part that derives from the other ingredient; namely, the common form that results from the causal equilibrium between the ingredients.<sup>6</sup> So, there is in a sense mingling of parts of different origin, deriving from different ingredients, in a mixture, but unlike the composition of barley and wheat, there is no mingling of natures in a mixture, because of the uniformity of all parts irrespective of derivation.

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<sup>6</sup> When discussing the barley-wheat type of composition, Aristotle says that they are not mixed because the composition is not a homoeomer: 'nor will the part have the same proportion [*logos*] as the whole' (328a9). It should not be thought that Aristotle is here defining uniformity in terms of the proportion of the ingredients being the same in every part of it as it is in the whole. This is clear from the fact that he immediately proceeds to give the example of water as a paradigmatic homoeomer. But it is also clear from the fact that he denies the possibility of division into infinitesimals (328a5-6) which would be a presupposition for such a definition of uniformity. What Aristotle is saying here is that in the barley-wheat composition we do not have even the same proportion of different ingredients in the part as in the whole (let alone the same stuff, as we do in the case of water).

The difference in origin of the parts in a mixture does not prevent the uniformity of the mixture. But does it have consequences for what can be derived from each part of the mixture? Aristotle in fact seems to make an even more stringent claim than that the initial ingredients of a mixture can be restored after they have been mixed. He seems to claim that any of the initial ingredients can be *derived*, not just from the mixture, but *from any part* of the mixture:

It follows [from Empedocles's account] that fire and water cannot come to be from any particle of flesh whatsoever, in the way that with wax, whilst from this part a sphere might come to be and a pyramid from some other, it would always be possible for it to happen the other way round. This does in fact occur in this way, i.e. from flesh both elements can come to be from any particle whatsoever. According to the account we have been discussing, however, it would not be possible: it would have to be the way that stone and brick come from a wall, one from one place and part, one from another. (334a31-b1)

This is *prima facie* a difficulty for the interpretation I am offering of Aristotle on mixing. On my explanation, the matter of the initial ingredients remains fragmented and deformed in the mixture. Isolating any such part of the mixture from the causal influence of the other parts of the mixture that are in contact with it would allow the compromised nature of the initial ingredient to be restored in that part, e.g. into water or earth. But Aristotle seems to claim here that from that part of the mixture either water, or earth could be derived.

The claim is *not* that in every part of the mixture both ingredients are *present*. This could be somehow explained by a presence of a compromised part of one ingredient at a place in a mixture, or by the presence of the causal influence of the other ingredient on it. These are two senses in which both ingredients are present in every part of the mixture. But the claim here seems to be more stringent. Aristotle appears to want either of the initial ingredients to be *derivable* from any part of the mixture [*ex hotououn amfō ginesthai*, 334b35], not just present in every part of the mixture. Nor does he mean that any particle of the mixture can produce both ingredients at the same time. His example of the pyramid and the sphere shows that when the mixture is dissolved, from any part either the one or the other ingredient will be restored.

I believe that if Aristotle is claiming the omni-derivability of a mixture's ingredients from the mixture, the claim is unsustainable. The reason is the following: suppose that in one case of dissolution of a mixture, all the original matter of one ingredient comes to constitute the other ingredient, and vice versa; e.g. all the matter of the water that went into the mixture comes to have the properties of earth, and all the matter of the original earth comes to have the properties of water. Then we do not have the recovery of the initial ingredients, but only of some earth and some water, generated from the mixture. The resulting elements are not the original ingredients because their matter has totally changed. If we took them to be the same, then any pool of water would also turn out to be identical to any other pool of water, and similarly for parcels of earth. Hence, if Aristotle's claim is that either ingredient can be derived from any part of the mixture, the claim is simply false.

But maybe, on the other hand, Aristotle does not say that either of the original *ingredients* can be derived from any part of the mixture, but only that either of the *elements* that the

mixture contains can be derived from any part of it: ‘from flesh both elements [i.e. fire and water] can come to be from any particle whatsoever’ (334b35). If Aristotle is here indifferent as to whether we derive new parcels of earth from a part of the flesh, or the original ingredients, then my account has no difficulty accommodating this. In the case of the generation of the new element from the mixture, external causal factors would need to explain its generation according to any account.

Aristotle does not give us the mechanics of how the original ingredients can be restored from a mixture, let alone how either ingredient can be restored from any part of the mixture, if this is being claimed at all. The account I offered above in terms of the original ingredients remaining fragmented and compromised in the mixture supplies the mechanism for the first, to complement what Aristotle explains about mixtures. What his claim is about the second remains a speculation, which on either reading of it does not add content to his account, but if anything, misleads.