

# The *De mixtione elementorum* of Thomas Aquinas

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## ABSTRACT

In this article Aquinas's three accounts of how the elements combine – those of Avicenna, Averroës and Aquinas himself – are considered. An attempt is then made to reinterpret these accounts in the light of our contemporary understanding of the manner in which the modern elements behave in combination. This follows Bobik's lead in restating Aquinas's own account of how the Aristotelian elements combine, using present-day insights into the behaviour of the modern elements.

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## I Introduction

*De Mixtione Elementorum* is a short work by St Thomas Aquinas. McDermott<sup>1</sup> states that its date of composition is uncertain, Bobik<sup>2</sup> gives 1273, and Larkin<sup>3</sup> quotes Mandonnet as giving it at about 1273, and Eschmann as 1270/71. Larkin goes on to say that in this work Aquinas takes up the problem of Aristotle's *De Generatione et Corruptione*, book 1, chapter 10, and considers two viewpoints on the question of how the forms of the elements remain in compounds. The first position he takes up, according to Larkin<sup>4</sup> is that these forms persist actually in the compound. After refuting it, he presents an opinion that tries to avoid the difficulties inherent in the preceding position, and those also that are entailed in the contention that the forms of the elements do not exist in the compound at all. Aquinas rejects this second opinion also and then reaffirms the Aristotelian solution.

McDermott<sup>5</sup> says that the philosophical questions asked by Aquinas would still have to be asked today by an Aristotelian philosophy of substance: in a compound what is the substance, only the elements, or both the elements and the compound, or only the compound? It is the intention of this essay to give an account of both *De Mixtione Elementorum* itself and of Grant's commentary on it, and to discuss Bobik's interpretation of the work.

## II *De Mixtione Elementorum*

### 2.1 Avicenna's Theory

The substantial forms remain, but active and passive qualities of the elements are somehow placed, by being altered, in an intermediate state, the reason being that if they did not remain, there would be a kind of corruption of the elements, rather than a combination. As Grant<sup>6</sup> says this topic was discussed by Avicenna in his *Sufficiencia*.

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<sup>1</sup> Timothy McDermott (Trans.) *Thomas Aquinas Selected Philosophical Writings*, Oxford (1993) p. 117.

<sup>2</sup> Joseph Bobik, *Aquinas on Matter and Form and the Elements*, Notre Dame (1998) p. xvii.

<sup>3</sup> V.R. Larkin 'St Thomas Aquinas: "On the Combining of the Elements",' *Isis*, Vol. 51, No. 1, (Mar., 1960), p. 67.

<sup>4</sup> *Ibid*, p. 68.

<sup>5</sup> McDermott, *op. cit.*, p. 117.

<sup>6</sup> Edward Grant, (ed.) *A Source Book in Medieval Science*, Harvard University Press (1974) p. 607.

According to Grant, Avicenna argued that the substantial or essential forms of the combining elements persist, unaltered, in a compound. With only their qualities altering and weakening, contrary qualities blend into a *complexio*, or mean quality. But the new complexions, or mean qualities, do not produce a new substantial form in the newly forming compound. Rather, they prepare the matter of the compound to receive a new substantial form that is infused directly by the '*dator formarum*', namely the agent intellect. This new substantial form is simply added to the four substantial forms of the elements already present in the compound. The properties or accidents of the compound are then finally determined by the new substantial form. Grant goes on to say that Avicenna's theory was almost without influence in the Latin west.

Aquinas<sup>7</sup> continues that if the substantial form of the compound is the act of matter, without presupposing the forms of the simple bodies, then the simple bodies would lose the nature of the elements, for an element is that out of which something is in the first instance formed, which remains in it, and which is by its nature indivisible, for if the substantial forms are withdrawn, the compound will not be formed from the elements in such a way that they remain in it. [This argument is drawn from Aristotle's *Metaphysics*, according to Grant,<sup>8</sup> who gives Aristotle's definition of an element as: 'the primary component immanent in a thing, and indivisible in kind into other kinds' (*Meta.* V. 3. 1014a 26-27).]. Aquinas<sup>9</sup> says that this cannot be the case, in that it is impossible for the same portion of matter to receive the forms of the different elements. He argues that if the substantial forms of the elements are preserved in the compound they must be in different parts of matter. But it is impossible for different parts of matter to receive them, unless it is assumed that quality is present in matter, for if quality is not presupposed, the substance would still be indivisible, as is made clear in the first book of the *Physics*, which Grant<sup>10</sup> gives as:

'If, then, being is both substance and quality, it is two, not one: if only substance, it is not infinite and has no magnitude; for to have that it will have to be a quality'.

(*Physics*, 1.2. 185b. 2-4)

Thus, according to Grant, if being is substance only, it will have no magnitude and will consequently be indivisible.

Aquinas<sup>11</sup> continues that a physical body is composed of matter that is subject to dimensions, and of a substantial form united to it, and therefore the different parts of the matter, that support the forms of the elements, receive the natures of several bodies. But he says: '*multa autem corpora impossibile est esse simul*'. The four elements will not then be in each part of the mixture, and hence there will not be a true mixture, but only an apparent one, as is the case when bodies, which are invisible or imperceptible due to their minuteness, are clustered together. Grant<sup>12</sup> explains that under the circumstances described here, if four elements constitute a given compound, each element will fully retain its identity and represent a part of the compound in complete isolation from the other three elements. Thus a compound would consist of four elements each occupying a different part of the compound, but unmixed in any matter. Hence it is not a true

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<sup>7</sup> *Ibid.*, p. 603.

<sup>8</sup> *Ibid.*, p. 603.

<sup>9</sup> *Ibid.*, p. 603.

<sup>10</sup> *Ibid.*, p. 603.

<sup>11</sup> *Ibid.*, p. 603.

<sup>12</sup> *Ibid.*, p. 604.

mixture or compound. Grant<sup>13</sup> goes on to explain that in *De Generatione et Corruptione* book 1, chapter 10, Aristotle has distinguished between what the scholastics were to call a *mixtio ad sensum*, which corresponds to a physical mixture, and a *mixtio secundum veritatem*, which corresponds more closely to our notion of a chemical compound. Grant goes on to say that how elements were contained in a compound was answered by Aristotle only very briefly and sketchily, and explained that: ‘since, however, some things *are-potentially* while others *are-actually* the constituents, combined in a compound can ‘be’ in a sense and yet ‘not-be.’ The compound may *be-actually* other than the constituents from which it has resulted, nevertheless each of them may still *be-potentially* what it was before they were combined, and both of them may survive undestroyed. The constituents, therefore, neither:

- a. persist actually, as ‘body’ and ‘white’ persist, nor
- b. are they destroyed (either one of them or both) for their ‘power of action’ is preserved (*De Generatione et Corruptione* 1.10. 327b. 24-31).

Grant<sup>14</sup> says that it was left to the scholastics to explain the mechanism by means of which an element could be said to have its power preserved in a compound and yet not actually persist. A number of solutions were proposed, the most important of which are discussed by Aquinas in the work under consideration.

Aquinas<sup>15</sup> continues that every substantial form demands a special disposition (*proprium dispositionem*) in matter, without which it cannot exist, as a result, alteration precedes generation and corruption. He states that it is impossible that the special disposition which is demanded by the form of water should be found in the same portion of matter, because it is on account of such dispositions that fire and water are contraries. It is impossible for contraries to be entirely present in the same thing at the same time, he argues, and therefore it is impossible for the substantial forms of fire and water to be in the same part of a compound (*in eadem parte mixti*). If then a compound is formed while the substantial forms of the elements remain, it follows that it is not a true compound, but only an apparent one, as when parts, indiscernible because of their smallness, are placed next to one another.

## 2.2 Averroës’s Theory

Aquinas<sup>16</sup> then says that some men wishing to escape both arguments, have fallen into a greater difficulty, and goes on to give Averroës’s account. In order to distinguish the combinations of elements from their corruption, they said the substantial forms of the elements indeed remain somehow in the compound, but lest they should be forced to admit that it is an apparent combination, and not a true one, they maintain that the forms of the elements do not remain in the compound in their entirety, but are reduced to some intermediary state, for they say that the forms of the elements admit of more or less, and are related to one another as contraries. But because this plainly contradicts the common opinion of men and of Aristotle in his *Praedicamenta* [According to Grant<sup>17</sup> the *Categories*, 5.3b. 24) ‘another characteristic of substances is that there is nothing contrary to them’, and 5.3b. 33: ‘For example, white, which is in a subject (the body), is predicated of the subject; for a body is called white. But the definition will never be predicated of the body’] that substance has no contrary and that it does not admit of more or less, they go

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<sup>13</sup> *Ibid.*, p. 605.

<sup>14</sup> *Ibid.*, p. 606.

<sup>15</sup> *Ibid.*, p. 604.

<sup>16</sup> *Ibid.*, p. 604.

<sup>17</sup> *Ibid.*, p. 604.

further, and say that the forms of the elements are the least perfect of all (*imperfectissimae*) as they are closer than others to prime matter, hence they stand midway between substantial and accidental forms (*mediae inter formas substantiales et accidentals*), and thus, inasmuch as they approximate the nature of accidental forms, they can admit of more or less, even though they are related to one another as contraries. But Aquinas dismisses this position for a number of reasons. First, because it is impossible for something to stand midway between substance and accident, as then there would be a mean between affirmation and negation. It is in the nature of the accident that it be in a subject, but in the nature of substance that it not be in a subject. And substantial forms are indeed in matter (*materia*) but not in a subject, for a subject is something individual. A substantial form is that which causes the individual subject. It does not presuppose it. Likewise, it is ridiculous to say that there is something midway between things which do not belong to the same genus, for the means and the extremes must belong to the same genus, as proved in Book 10 of Aristotle's *Metaphysics*, in which he says: 'for all intermediates are in the same genus as the things between which they stand'. Therefore there can be no mean between substance and accident.

Aquinas<sup>18</sup> gives another example in which he states that it is impossible for the substantial form of the element to admit of more or less. He elaborates on this by saying that every form that admits of more or less is accidentally divisible inasmuch as the subject can participate in it more or less. Now, he says, one finds continuous motion in that which is divisible essentially or accidentally, as is made clear in Aristotle's *Physics*, which Grant<sup>19</sup> gives as *Physics* VI.2. 233b. 15, 31 in which Aristotle says: '... neither a line nor a surface nor in fact, anything continuous, can be indivisible' and 'it is evident, therefore, that nothing continuous is without parts', respectively.

Aquinas says that one has as examples change of place, and growth and decay with respect to space and quality which are essentially divisible, and alteration with respect to qualities, such as hot and white, that admit of more or less, there will be continuous motion in both the generation and corruption of the elements, but that this is impossible, for continuous motion exists in three genera, namely quantity, quality and place, as is proved in Aristotle's *Physics* Book 5, given by Grant as *Physics* V.1. 225b. 9, in which Aristotle says 'There are three kinds of motion – qualitative, quantitative and local'.

Furthermore, even difference in substantial form results in a change of species, and what admits of more or less, and is in some way contrary to it, as in the case of the more white and the less white. If then the substantial form of fire admits of more or less, it will result in a change of species, according as it is more or less realised, and it will not be the same form but another one. Aquinas<sup>20</sup> then quotes Aristotle in the eighth book of the *Metaphysics*, that just as the species is changed in the case of numbers by addition and subtraction, so also is it changed in the case of substances. He concludes that some other explanation must be found by which the truth that a combination is effected and that the elements are not wholly destroyed but remain in some way in the compound may be safeguarded. He then goes on to state his own solution to the problem.

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<sup>18</sup> *Ibid.*, p. 604.

<sup>19</sup> *Ibid.*, p. 604.

<sup>20</sup> *Ibid.*, p. 605.

### 2.3 Aquinas's own Theory

Aquinas<sup>21</sup> first considers that the active and passive qualities of the elements are related to one another as contraries, and admit of more or less. From these contrary qualities there can be formed a mediant quality which partakes of the nature of each extreme, and he gives as examples grey which lies between white and black and warm which lies between hot and cold. Thus, when the perfections of the qualities of the elements are modified, there is formed from them some kind of mediant quality which is the quality characteristic of the compound and which differs in different compounds according to the different proportions of the combinations, and the quality is, in fact, the disposition that belongs to the form of the compound, just as the elementary quality is the disposition that belongs to the form of an element. He argues that the quality of an element is indeed distinct from its substantial form. However, it acts by virtue of the substantial form, otherwise, heat would merely warm, and not by its power would a substantial form be brought to actual existence, for a thing's activity cannot transcend its nature.

Aquinas<sup>22</sup> argues that in this way the powers of the substantial forms of the elements are retained in compounds. As Grant<sup>23</sup> explains, that is, through the elemental qualities which united to form the mediant quality, which becomes the characteristic quality of the compound. Aquinas concludes that the forms of the elements are present in compounds not actually but virtually, and that this is what Aristotle says in the first book of *De Generatione et Corruptione*, given by Grant<sup>24</sup> as 1.10. 327b. 30-32.

'The elements do not remain actually in the compound, as body and white do, and neither one of them nor both of them are destroyed or altered; for their power is preserved.'

## III Discussion

### 3.1 Avicenna's Theory

In Bobik's<sup>25</sup> analysis of this theory the elements remain with their substantial forms, but their active and passive forms have been changed into some sort of mean. He says that Aquinas points out that the active and passive qualities of a mixed body are different from, and are some sort of mean between, those of each of its constituent elements, for if they were not different, it would be impossible to differentiate the mixed body from its elements. For a thing acts, and is itself acted upon, according to what it is. But the elements themselves, in a mixed body, must remain unchanged, must retain their substantial forms. Because, if this were not the case, the elements would have been corrupted and, just as it is impossible for a whole to be made up of constituents which no longer exist, so too is it impossible to have a mixing of elements out of elements which no longer exist.

Bobik<sup>26</sup> says that they (the Avicenneans) argue secondly, as Aquinas notes, that if the substantial form of a mixed body were to inform prime matter directly, so that the forms of the now-constituting simple bodies had perished, then the simple bodies would not

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<sup>21</sup> *Ibid.*, p. 605.

<sup>22</sup> *Ibid.*, p. 605.

<sup>23</sup> *Ibid.*, p. 605.

<sup>24</sup> *Ibid.*, p. 605.

<sup>25</sup> Joseph Bobik, *Aquinas on Matter and Form and the Elements*, Notre Dame (1998) p. 106.

<sup>26</sup> *Ibid.*, p. 106.

fulfil the definition of an element. For, whatever else an element is, it is something which remains in a mixed body.

Both of these argument, Bobik<sup>27</sup> says, begins by supposing that the substantial forms of the simple bodies do not survive in the mixed body. But, whereas the first argument notes that, in that case, there would not be a mixing of simple bodies, but a corruption of them, the second argument notes that, if that were the case, the simple bodies could not be elements, because they would not remain in the mixed body. To have a mixing out of simple bodies, urges the first argument, one must have the simple bodies, but the second argument insists that for the simple bodies to be elements, they must remain in the mixed body as its ingredients.

Bobik<sup>28</sup> employs Aquinas's reasoning to consider the matter in a contemporary context, and considers the case of water, taking water as a mixed body, and oxygen and hydrogen as its elements. Do oxygen and hydrogen 'remain intact' in water? It seems that they do, in some way at least, for they can be retrieved. Bobik<sup>29</sup> ponders whether their active and passive qualities have been altered, or changed into some sort of mean. And indeed, what are the active and passive qualities of hydrogen and oxygen, i.e. before they become constituents of water? What is the mean, i.e. what are the active and passive qualities of water, in terms of which water is to be differentiated from oxygen and hydrogen? And what is it that oxygen does to hydrogen, and *vice versa*, to produce this mean quality (or qualities) which is the mean quality (or qualities) proper to water?

Bobik<sup>30</sup> argues that, if the substantial forms of hydrogen and oxygen remained in water, then water would be water throughout, yet simultaneously hydrogen in certain of its parts, and oxygen in certain other of its parts, which is quite clearly impossible, he says. It must be the case then that, when hydrogen and oxygen become constituents of water, they cease being hydrogen and oxygen respectively, because water is water, and just water. Nonetheless, both oxygen and hydrogen must remain in some way in the water. For both are retrievable. But how exactly do they remain? Whatever the way in which they remain, they cannot remain precisely as hydrogen and oxygen, each with its appropriate substantial form. Could it be that they remain by reason of their active and passive qualities, but as altered somehow into some sort of mean qualities, which are the qualities appropriate to water?

Bobik<sup>31</sup> examines the difference between a true mixing (*vera mixtio*) and a mixing only to sense (*mixtio ad sensum, secundum sensum, solum*). He asks whether Aquinas is suggesting, by implication at least, that in a true mixing the four elements (or however many of them are required by the substantial form of the mixed body) are found in any and every part (*in qualibet parte*) of the mixed body. For he writes:

*'Non igitur in qualibet parte corporis mixti erunt quatuor elementa. Et sic non erit vera, mixtio, sed secundum sensum ...'*

If this is indeed what Aquinas is suggesting, then it is clear that the elements cannot be in the mixed body with their respective substantial forms. For a mixed body is just whatever it is, and throughout. It is certainly true, Bobik<sup>32</sup> argues, that water (taking water as a mixed body) is water throughout, that every part of water is just water, and that no part of water is either hydrogen or oxygen (taking these as the constituting elements). And this clearly implies that, however it is that the elements survive in a mixed body, they cannot survive with their respective substantial forms. In a mixing

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<sup>27</sup> *Ibid*, p. 106.

<sup>28</sup> *Ibid*, p. 107.

<sup>29</sup> *Ibid*, p. 107.

<sup>30</sup> *Ibid*, p. 108.

<sup>31</sup> *Ibid*, p. 111.

<sup>32</sup> *Ibid*, p. 111.

which is a mixing to sense only, on the other hand, the parts which make up the resulting body remain, each of them, with their respective substantial forms. So that, if water were a mixing only to sense, some parts of the water would be oxygen, other parts would be hydrogen, and the water itself would not be water at all, let alone throughout. Water would only be a collection of juxtaposed atoms of hydrogen and oxygen. Furthermore, it would not have the qualities which we know to be proper to water. Rather, some parts of it would have the qualities of hydrogen, other parts, the qualities of oxygen. So how then are the elements hydrogen and oxygen present in the mixed body, water?, Bobik<sup>33</sup> asks. Not actually – this is clear. Potentially then? This seems the correct thing to say, for what other alternative is there? But what exactly does this mean? Are we to say, as it seems Aquinas would (if he had taken water to be a mixed body) that what this means is that it is their active and passive qualities which remain but as altered into water's appropriate mean qualities by their water-constituting interaction? And are we to take this to mean, as it seems Aquinas would, that the substantial form of water is both brought into existence, and having been brought into existence, acts through these mean qualities, until such time as some external agent (or agents) 're-alter' water's mean qualities, i.e. nullifies the prior water-constituting interaction between oxygen and hydrogen, releasing thereby their extreme elemental qualities, and in turn bringing about their re-generation as actual, and separately existing and acting, physical entities?

In a true mixing thus, Bobik<sup>34</sup> argues, the elements do not survive with their respective substantial forms. What survives is their active and passive qualities, appropriately changed by alternation into a set of mean qualities. These mean qualities serve as:

- i. the disposition by which the mixed body is brought into existence,
- ii. as that by which the mixed body acts, and
- iii. as that by the removal of which the elements are released to exist again as actual, separate and free physical realities.

In a mixing to sense only Bobik<sup>35</sup> says, the ingredients survive with their respective substantial forms. Such a mixing is just a collection or gathering of juxtaposed things – not mixed, since they have not altered one another by some appropriate interaction – each of which is so small that neither they nor their juxtaposition is perceptible to sense, but to sense only, such a mixing may, in some cases, appear to be a true mixing.

Bobik makes a clever argument in drawing attention to the shortcomings of Avicenna's analysis of the problem of how the elements blend by using as examples hydrogen and oxygen and how, if these two elements retain their substantial forms as elemental hydrogen and elemental oxygen, they will not form water. It could be argued, however, on Avicenna's behalf, that if one were to consider some solutions of water soluble materials, one might see some justification for Avicenna's position.

One might take as examples the two crystalline materials, copper sulphate and common salt (taking these as 'earth') which are perfectly water soluble (at least up to their limit of solubility). Copper sulphate is a blue crystalline solid, which dissolves in water to form a blue solution. The higher the concentration of copper sulphate the bluer the solution. It could be argued that copper sulphate solutions satisfy the scholastic's criterion of a *mixtio secundum veritatem* as there is no doubting the completeness of the mixing process as the solutions are perfectly clear under every scrutiny, demonstrating that the copper sulphate has indeed dissolved completely in the water. Yet the solutions

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<sup>33</sup> *Ibid*, p. 112.

<sup>34</sup> *Ibid*, p. 112.

<sup>35</sup> *Ibid*, p. 112.

are both blue and aqueous, proving that they really are composed of blends of copper sulphate and water. But the strength of the blue colour of a given solution is in direct proportion to the amount of copper sulphate in that solution, the higher the proportion of copper sulphate the bluer the solution. An Avicennean might well argue that this is a consequence of the copper sulphate and the water each preserving its substantial form in the solution but blending its accidental properties with the other material. There is no doubting that both water and copper sulphate are present in the solutions, and an obvious property of each – water-whiteness in the case of water, and blueness in the case of copper sulphate – are also present, but in proportion to the amount of each one. Reduce the amount of water and the solution is bluer, showing the greater influence of the copper sulphate, increase the amount of water and the colour becomes less blue (or more water-like). In each case the presence of the substantial forms of the two materials is still evident, all of the solutions under consideration are composed of copper sulphate and water, but the accidental properties of each material, water-whiteness and blueness, vary as the relative proportions of the two materials vary. As the concentrations of the water and the copper sulphate vary, their accidental properties also vary. The colour of a given solution is simply an averaging out of the colours of the two materials from which the solution is made. An Avicennean might argue that the two elements, water and ‘earth’ (copper sulphate) retain their substantial forms in solution, but that they average their accidental properties, in this case their colours, when they form a solution.

A similar case could be made in the case of solutions of common salt in water, only this time the solutions are colourless. However, the presence of the salt is indicated by the saline taste of the solution. Here again the Avicennean might argue that the accidental properties of the salt solutions, taken in this case to be represented by the saline taste of the solutions, are in direct proportion to the relative amounts of salt and water present in the solutions. A high proportion of salt in solution gives a very saline taste, a low proportion of salt gives a less saline, or more aqueous taste. An Avicennean might argue that the substantial forms of the two elements, water and ‘earth’ (common salt) are retained in solution, but that their accidental properties, in this case their taste, are averaged out.

### 3.2 Averroës’s Theory

The elements remain with their substantial forms, but the substantial forms themselves have been changed into some sort of mean. Bobik<sup>36</sup> says that according to this argument the substantial forms do indeed survive in the mixed bodies, in some way, and for the same reason, i.e., in order to be able to claim that mixed bodies come into existence by a mixing of elements, not by a corruption of them. But unlike those other thinkers, who hold that the active and passive qualities of the elements take on degrees of more and less, these thinkers maintain that it is the substantial forms themselves of the elements that take on degrees of more and less, and they do this in order to avoid having to say that the mixing is a mixing only to sense. The mixing, they say, is a true mixing, because the substantial forms of the elements survive, though not in their fullness. These forms have been reduced by alteration to a kind of mean, since they can take on degrees of more and less, and this mean is the form appropriate to the mixed body which has come into existence.

However, Bobik<sup>37</sup> states that Aquinas points out that these thinkers go further and argue that the substantial forms of the elements are of a most imperfect sort, since they are so close to prime matter, so close that nothing can be closer. (This is contrary to the common opinion, Aquinas states, and to Aristotle in the *Categories*, that a substance

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<sup>36</sup> *Ibid*, p. 114.

<sup>37</sup> *Ibid*, p. 115.

has no contraries, nor does it take on degrees of more and less). From which they conclude that these substantial forms are in some sense midway, a kind of mean, between substantial forms generally and accidental forms. They are less perfect than other substantial forms, and so can take on degrees of more and less, and have contraries. But they are more perfect than accidental forms, and so can account for the existence of substances.

Bobik<sup>38</sup> says that Aquinas dismisses this position as unacceptable in many ways, for it is altogether impossible that there can be something midway, a mean, between substance and accident. For in that case, there would be a mean between affirmation and negation, since it belongs to an accident to exist in a subject, and to a substance not to exist in a subject. A thing either is, or is not, there is no in-between. If there were, then there would be something which neither is nor is not. There cannot be something which is, but is neither a substance nor an accident, nor can something be a substance up to a point, and simultaneously an accident up to a point. If something exists, it is either a substance or an accident. It cannot be, and not be either.

Substantial forms are in matter, but they are not in a subject, i.e. not in an actually existing subject. For an actually existing subject is a substance – a *hoc aliquid* – some actual individual thing. An accident presupposes the existence of a subject. A substantial form, on the other hand, does not. By way of significant difference, a substantial form is precisely what accounts for the existence of the subject. Besides, the means and the extremes must belong to the same genus, as is proved in book ten of the *Metaphysics*. If there were a mean between substance and accident, it would follow that substances, accidents and substantial forms, all three, would be substances, or that all three would be substantial forms. All of which suppositions are unacceptable, and so to be rejected.

Bobik<sup>39</sup> goes on to say that Aquinas states that it is impossible for the substantial forms of the elements to take on degrees of more and less. For if they did, then both the generation and the corruption of the elements would be a motion which is a continuous one. But this is impossible, because the generation and corruption of the elements are motions in the genus of substance. Motion is continuous, Aquinas notes, if it is divisible, whether divisible *per se* or *per accidens*, as is clear in book six of the *Physics*. Now, change in place, and increase and decrease in size, i.e. growth and its opposite, diminution, are motions which are divisible *per se*, since both place and quantity are divisible *per se*. Alteration, on the other hand, is a motion which is divisible *per accidens*, i.e. because of qualities which take on degrees of more and less, like hot and white. So that, if the substantial forms of the elements were to change so as to take on degrees of more and less, the change would be a substantial change, and at the same time a motion which is divisible *per accidens*. And so, the substantial forms of the elements would be undergoing a motion which is continuous, and which is in the genus of substance. But this is impossible, because motion is continuous in three genera only, i.e. in quantity and quality and where, as is proved in book five of the *Physics*.

Moreover, Aquinas adds, every difference in substantial form varies, or changes, the species. It is clear that what takes on degrees of more and less is different from what is less, and is in some way contrary to it. For example, a thing A, which becomes even *more* white than something else, B, which was already less white than A; or a thing, A, which becomes *less* white than something else, B, which was previously less white than A. In both cases, A differs from B, and is in some way contrary to B. So that, if the substantial form of fire, takes on degrees of more and less, then, whether it becomes more firey than it was, or less firey. In either case it will not be the same form, but another. That is, the more firey fire will not be fire, or, not fire of the same species. The

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<sup>38</sup> *Ibid*, p. 118.

<sup>39</sup> *Ibid*, p. 119.

less firey fire too, will not be fire, or, not fire of the same species. For, in either case, there would have been a substantial change. And this is what Aristotle had in mind when he wrote, in book eight of the *Metaphysics*, that just as numbers differ in species because of degrees of more, i.e. addition (of units), and degrees of less, i.e. subtraction (of units), so, too, do substances differ in species, but by the addition and subtraction of *differences* (rather than units).

Bobik offers no discussion on Averroës's argument. This may simply be due to the difficulty of applying contemporary insights into the nature of the elements to construct a model in which the substantial forms of the elements might somehow be averaged out. For example, just how the substantial forms of H<sub>2</sub> and O<sub>2</sub> might be made to form an average is not easy to visualise. However, a second way of considering how two distinct substantial forms might combine, blend or mix to give a product a new substantial form, which could genuinely be regarded as their average, could be rationalised by examining the case of hybrids. Although no mention of hybrids is made by Aristotle in his *De Generatione et Corruptione*, nevertheless the principles of animal hybridisation were well understood by ancient peoples, if for no other reason simply because of the breeding of mules.

A mule is sired by a donkey, with a horse as dam, and is bred specifically because it embodies useful characteristics, both asinine and equine in origin. These characteristics include the strength and stamina of a horse, and the sure-footedness and manoeuvrability of a donkey. This means that strength and stamina, obvious equine characteristics, are possessed of an animal not belonging to the species *equus*, and similarly, asinine characteristics of sure-footedness and manoeuvrability are possessed of an animal not belonging to the species *asinus*. A mule is neither a horse nor a donkey, but somehow combines qualities of both species, and in appearance seems to resemble both of its parents. The *virtutes* of a horse are present in an animal which is clearly not of the species *equus*, and those of a donkey are present in an animal not of the species *asinus*. The species *mulus* exists in its own right, but with *virtutes* inherited from both its equine and asinine parents.

An Averroean might argue that the existence of hybrids could be taken as evidence that the substantial forms of two substances can be mixed or blended to give a new substance, distinct from, yet obviously related to both. He might also argue that the principle of hybridisation demonstrates that when substances are hybridised some of the characteristics of each are transmitted in their entirety to the new substance. He could also argue that a principle active in biological systems could have wider applications in nature, perhaps extending to the behaviour of the elements. He could reason that the elements must somehow be present in the various substances found in the world, and, in addition, their accidental qualities must somehow be transferred to the new substances formed when those elements combine. Hybridisation of the blending elements, combined with the conservation of some of the characteristics of each individual element, might provide a mechanism by which this could occur.

### 3.3 Aquinas's own Theory

The elements remain with their powers and with retrievability, but not with their substantial forms.

Bobik<sup>40</sup> says that Aquinas begins to give what he takes to be the proper answer to the question: how are elements in a mixed body?, an answer which will both:

- a. safeguard that the mixing is a true one, rather than to sense only, and

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<sup>40</sup> *Ibid*, p. 120.

- b. make certain that the elements have become, and remain, ingredients of the mixed body, and so have not been totally corrupted.

A true mixing requires that the elements have interacted and have changed one another in some way, but the change cannot be so radical as to have been their total corruption. Still, the elements must have been corrupted – at least in some way – otherwise the mixed body could not have been generated. Nonetheless, the elements must remain – at least in some way – otherwise the elements cannot be ingredients of the mixed body. And so, the generation of a mixed body out of elements requires that these elements be both corrupted and not corrupted.

Bobik<sup>41</sup> says that Aquinas begins by pointing out that it is the *active and passive qualities* of the elements, and not their substantial forms, which are contrary to one another, and take on degrees of more and less. And one can add to this that the elements change, and are changed by, one another, precisely by means of, and with respect to, their active and passive qualities. Thus, when the *excellencia* – the hottest, the coldest, the driest, the wettest – which is the proper degree of some elemental quality, meets with the most which is the proper degree of some other elemental quality, there results an interaction which tempers or diminishes both extremes, the result being some sort of more or less, some sort of in-between, mean quality. Now, this mean quality is the proper or distinguishing quality of some mixed body, different mixed bodies having appropriately different mean qualities, some closer to one extreme, some closer to the other extreme. And it is through this *mean* quality, as though the required proper disposition, that alteration, as the way to the *generation* of a mixed body, brings the mixed body into existence out of the required elements, mixed according to an appropriate proportion, just as it is through the *extreme* quality, as through the required proper disposition, that alteration, this time as the way to the *corruption* of a mixed body, retrieves, and thereby brings back into existence, the elements which had been the required ingredients of the now-corrupted mixed body.

Bobik<sup>42</sup> says that Aquinas notes that the qualities of the simple bodies, i.e. of the elements, are found in the proper quality of a mixed body in a way which is similar to the way in which extremes are found in a mean which participates in the nature of each of them. Bobik exemplifies this with water, hydrogen and oxygen (taking water as a mixed body, and hydrogen and oxygen as its elements). One can say that the active and passive qualities of water are a mean of some sort, which participates in some way, in the extremes which are the active and passive qualities of hydrogen and oxygen. And it is not at all necessary for this mean quality to be anything at all like either of the extreme qualities, and it may even turn out to be a surprise of some sort, even a complete surprise – oxygen supports burning, whereas water quenches it.

Bobik<sup>43</sup> states that Aquinas comments on the relation between the qualities of the elements and their substantial forms. He begins by emphasising the fact that the quality of a simple body, or element, is other than its substantial form. Then he makes his main point, namely that the quality of an element acts under the influence, guidance (*in virtute*) of its substantial form. In other words, the element acts as it does because of the qualities which it has, and the qualities which it has are due to its substantial form. The substantial form of an element, once brought into existence, is not only continuously productive, and receptive, of the proper or distinguishing quality of that element, but performs its proper acts through that quality. Otherwise, the heat of fire would do nothing but make things hot, and the substantial form of fire would not be brought to a

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<sup>41</sup> *Ibid*, p. 123.

<sup>42</sup> *Ibid*, p. 123.

<sup>43</sup> *Ibid*, p. 124.

state of actuality through fire's heating action on a combustible material. For nothing can produce that which is beyond its kind. Fire produces fire, its own kind, through its proper quality or power, i.e. heat, but *in virtute* of its substantial form. Neither, Bobik adds, would the substantial form of water, taking water to be a mixed body, be brought to a state of actuality via the interaction between the proper qualities of hydrogen and oxygen, unless this interaction took place *in virtute* of their substantial forms, as well as of the substantial forms of other things, to be discovered by careful investigation, which might be required to bring about the substantial change in which water is generated.

Bobik<sup>44</sup> says that Aquinas concludes that it is *in this way* that the *virtutes* of the substantial forms of the simple bodies survive in mixed bodies. But in what way?, since Aquinas does not make this explicit. It seems that he is making a reference to his earlier statement that the qualities of simple bodies are found in the proper quality of a mixed body in a way which is much like the way in which extremes are found in a mean which participates to some extent in the nature of each of them. Accepting this, one can say that the *virtutes* of the substantial forms of the elements survive in mixed bodies, but not the substantial forms themselves. And so, the elements have been corrupted with respect to their substantial forms, but they have not been corrupted with respect to their qualities. These elemental qualities survive in the mixed body as tempered mean qualities.

Bobik<sup>45</sup> gives as an example the case of hydrogen and oxygen becoming water, what *is there*, he says, is neither hydrogen nor oxygen, but water. That is, hydrogen and oxygen are not there actually, though they are there potentially, and in two senses of 'potentiality':

- i. virtually (by their power), and
- ii. retrievably.

Water, nonetheless, does what water does, through its appropriate mean qualities, which are nothing but the now-tempered qualities of what were earlier, i.e. before the water came into existence, the 'excelling' qualities of hydrogen and of oxygen, as separately existing entities. It is the now-tempered (formerly excelling) qualities which actually survive, and actually remain, in the mixed body, and now under the influence or guidance, *in virtute*, of the substantial form of that mixed body.

According to Bobik<sup>46</sup> Aquinas gives a summary of how elements are in a mixed body. They survive, and are there, not by reason of their substantial forms, but by reason of their powers, i.e. qualities. The forms of elements are in mixed bodies not actually, but virtually (by their power). None of the elements is completely corrupted, neither is any of them completely preserved. As Aristotle puts it: 'What is preserved is their power.'<sup>47</sup> And their power, precisely because it is preserved, is retrievable. So are their substantial forms retrievable, and again via their power, functioning as the appropriate disposition? Thus, the substantial forms of the elements are not actually present in mixed bodies. Each mixed body has its own, single, substantial form, and it is this substantial form which manifests *its* proper activities through its proper qualities, which had been the extreme, or excelling, qualities now brought, or tempered, to a mean, of the formerly separately existing elements. The mixed body, like any corporeal substance, can have actually *but one* substantial form, its own. Potentially, however, i.e. both virtually, in their power, and retrievably, it has as many substantial forms, in number and in kind, as the elements which are required as its ingredients.

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<sup>44</sup> *Ibid*, p. 124.

<sup>45</sup> *Ibid*, p. 125.

<sup>46</sup> *Ibid*, p. 125.

<sup>47</sup> *Ibid*, p. 122.

On considering the three arguments presented by Aquinas, it could be argued that he himself gave the account of how elements are present in compounds most easily reconciled with contemporary scientific understanding of the matter. In his analysis of the question under consideration he is anxious to state that the elements in combination are not totally corrupted (*non totaliter corrumpantur*) but remain in some way in the blend. In addition, the qualities (*virtutes*) of the substantial forms of the simple bodies are preserved in the blend.

Continuing with Bobik's example of water, composed of the elements hydrogen and oxygen, and taking elemental hydrogen as consisting of two hydrogen atoms in combination to form a hydrogen molecule, and similarly elemental oxygen as two atoms of oxygen combined with each other to form an oxygen molecule, one could say that a molecule of the element hydrogen is split or 'corrupted' into its two constituent atoms, and that these atoms combine with an atom of oxygen, likewise formed from the splitting or 'corrupting' of a molecule of oxygen, to form a molecule of water. Of course the 'corrupting' of hydrogen and oxygen molecules, understood in this way, really refers to the splitting of these molecules into atoms, which then react together to form molecules of water. When the molecules of hydrogen and oxygen split and then reacted to form water, a genuine compound was formed, water, ensuring Aquinas's requirement of the preservation of the truth of the blend (*veritas mixtionis salvetur*) and also his requirement that the elements are not totally corrupted (*non totaliter corrumpantur*), as elemental hydrogen and oxygen simply change from their molecular- to their atomic-state, and retain their properties as hydrogen and oxygen.

In addition, Aquinas posited that the specific properties of the constituent elements of a compound would be averaged out (or to give his own example, *sicut pallidum inter album et nigrum*) as between the two elements. And this is borne out, for example, in the case of water, of which the molecular weight (18) is simply equal to the atomic weight of an oxygen atom (16) added to that of two atoms of hydrogen (2).

His insistence that the virtues of the substantial form (*virtutes formarum*) be preserved in the blended bodies holds true for water, as both elemental hydrogen and oxygen can be reconstituted from water – demonstrating that their 'corruption' is indeed reversible. And a point made by Aristotle<sup>48</sup> though not alluded to either by Aquinas or Bobik, is also fulfilled in the case of water. For when Aristotle says that 'things that are mixed manifestly come together from having formerly been separate, and are capable of being separated again' he may have been referring to the fact that whatever transformations elements undergo in forming compounds can be reversed in some way, so that the original elements can be reconstituted from their compounds. Presumably Aristotle believed that the elements reconstituted in this way would retain their special active and passive qualities.

In considering Aquinas's analysis of how elements are present in compounds, it is possible to attempt an understanding of the problem in terms of the medieval concepts of how the elements are constituted and behave, but it is also possible to understand the matter in terms of the insights brought to bear on the matter by modern scientific theory. Of the three arguments presented by Aquinas, his own seems best to accord with contemporary insights on the nature and behaviour of the elements. Why this should be may simply be due to his ability as a logical thinker to think the problem through, and to realise that if the elements were to form a true compound (*mixtio secundum veritatem*) the elements themselves would have to change or transform in some way so as to allow their true combining. But their specific properties would somehow have to average out with

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<sup>48</sup> *De Generatione et Corruptione*, 1.10. 327b 28-29.

those of the other elements in order to permit the formation of a compound having properties influenced by each of its constituent elements.

#### IV Conclusion

At the centre of the subject under discussion by Aquinas is the question of taking elements, each with its own nature and active and passive qualities, and creating a logical system which could account for the way in which these elements might combine with one another, but in such a way that they did not violate the rules of how substances behave, as laid down by Aristotle. This question imposes real demands on the thinker as the elements are substances and have forms. As well as having active and passive qualities, they may exist actually or potentially. If these elements are to combine so as to give a true mixing (*vera mixtio*) and not just a mixing to sense (*mixtio ad sensum*) surely they will have to change somehow in order to fulfil this requirement?, and do this without losing their identities as substances, or remitting their qualities. But how can they do so without losing their identities as substances, or compromising their properties in some way? Avicenna, Averroës and Aquinas all attempted to deal with the question and offer a satisfactory account of this matter.

Aquinas skilfully employs arguments put forward by Aristotle to disprove the theories of Avicenna and Averroës and to validate his own theory. Maier<sup>49</sup> says that in his analysis Aquinas offers a '*tertio opinio*' which stands beside those of Averroës and Avicenna, and together with which provided the point of departure (*Ausgangspunkt*) for the discussion of the problem in the late thirteenth and fourteenth centuries.

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<sup>49</sup> Anneliese Maier, *An der Grenze von Scholastik und Naturwissenschaft*, Rome (1952) p. 35.