Chapter 2
Theory Choice in Medieval Alchemy

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Theory choice is not a term often used in the context of medieval alchemy. Alchemists aspired to achieve extraordinary and, by our standards, *impossible* transformations: the transmutation of base metals into gold, the prolongation of human life, and the attainment of celestial perfection even within the flawed elemental world. They justified these ends with reference to a variety of ideas and explanations, ranging from analogies with the natural world to comprehensive physical theories. Since a variety of explanations and approaches were available, they sometimes had to choose between them. Even though it is not obvious that we can discuss alchemical ideas within the same framework as that used for modern scientific theories, the fact that alchemical explanations were not given arbitrarily nevertheless raises some interesting questions about what "theory choice" involves.

I shall begin with two caveats: one to do with medieval science, and one to do with theories.

Edward Grant has described medieval science as "empiricism without observation" [1, 2]. Its principles were discussed and refined without necessarily being subjected to empirical testing. This is not to say that medieval people had no science, nor that they were incapable of amending explanatory frameworks in order to accommodate observations. However, it does mean that received wisdom from authoritative sources generally carried far more weight than it does today, even when flawed. Rather than speaking of "science," I shall therefore use the contemporary scholastic category of "natural philosophy" to describe the medieval pursuit of natural knowledge.

Natural philosophy was concerned with events in the terrestrial world: a sphere composed of the four Aristotelian elements of earth, air, fire and water. In that

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world, change was explained in terms of the imposition of new specific forms onto a basic material substrate—for instance, when good wine became corrupt or sour, the form of the wine was replaced by that of vinegar. Ideas about alchemical transmutation were also expressed in terms of matter and form, even if these explanations were not set out with the level of detail and rigour that modern scientists demand of their theories.

The second caveat concerns my use of "theory." Alchemical texts are often (although not always) divided into two parts: *theorica* and *practica*. The practica usually provides an ensemble of recipes for a range of alchemical products, including transmutational elixirs, medicines, blanchers, pigments, and artificial gems. The theorica generally comes first, providing an introduction to the operative section of the treatise, and outlining some fundamental systems and explanations. The theorica might, for instance, discuss the system of Aristotelian elements and the relationship between matter and form; the manner by which metals are generated in the earth; the composition of the various metals and their characteristic properties; and so on. This introduction, often influenced by Aristotelian natural philosophy, provides the basic understanding of metallic substances necessary to support the next level of explanation: namely how one kind of metal may be transformed into another.[1]

A present day scientist might object that such understanding would be better described as a *world view*, or a *cosmology*, or a *framework*, rather than a theory or hypothesis in the modern sense. For instance, while medieval authors often suggest explanations for alchemical transmutation, the "truth" of such explanations may seem to be assumed, rather than supported by clear, testable, replicable hypotheses. Nevertheless, these explanations do reveal a real engagement with contemporary natural philosophy and with empirical results. To avoid ambiguity, I shall adopt an archaic English term, "theorick," when referring to the explanations of alchemical change proposed by medieval alchemists.

Which brings us to alchemy itself. Clearly, in the context of theory choice, alchemy poses particular problems. How can we discuss the falsification of an approach that we already *know*, from our privileged historical vantage point, could not have worked? In the case of alchemical transmutation, the very phenomenon that each theorick purports to explain is known to be impossible—or at least, impossible using the techniques available to medieval practitioners. Is it even meaningful to assess alchemical theories using the standards suggested by Kuhn [3] —of accuracy, consistency, broad scope, simplicity, and fruitfulness?

Alchemists were, in fact, deeply concerned with the rationality of their pursuit. Although widely practised, alchemy was never formally part of the university curriculum, so its practitioners sought alternative ways of legitimising it as a subject worthy of serious intellectual consideration [4]. Historians of science have therefore found it fruitful to concentrate on demarcation problems: asking how theories of transmutation arose in response to critique from medieval sceptics. These scholars

[1]For a more detailed introduction to alchemical ideas, see Lawrence M. Principe, *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2012).

have sought to show that alchemical ideas were rational according to the standards of medieval natural philosophy. Indeed, William Newman has gone so far as to argue that alchemy was actually *more* empirically grounded, and hence capable of offering better explanations of observable phenomena, than standard Aristotelian physics [5]:

> The alchemists of the High Middle Ages established an experimentally based corpuscular theory that would develop over the course of several centuries and eventually supply important components to the mechanical philosophy of the Scientific Revolution.

Yet this "corpuscular theory" is only one (albeit an influential one) among several kinds of explanation encountered in medieval alchemy, and practising alchemists did not always agree. This raises a new question: why did alchemy's supporters opt for one explanation rather than another? Were they intrested in explanatory power, empirical evidence, or consistency with other natural philosophical doctrines (including the works of past adepts)? Rather than asking how alchemists attempted to justify their art to sceptics, I shall investigate alchemists' engagement with *one another*, by considering some basic disagreements between different views of alchemical transmutation.

2.1 The Nature and Genesis of Metals: Competing Views

I shall start by outlining three different views on the nature and generation of metals, which all rely on the same basic idea—usually referred to as "Sulphur-Mercury theory."

Medieval views on the structure of metals were influenced by a tradition originating in Aristotle's *Meteorology*, and subsequently developed by medieval Islamic authors, including the semi-legendary alchemist Jābir ibn Hayyān, and the Persian polymath Ibn-Sina, or Avicenna.[2] According to this view, metals were formed within the earth by the commixtion of two vapours, or exhalations. One, a moist, smoky vapour, was described as "Mercury" —not elemental quicksilver, but a principle of moistness and fluidity. The second principle, a dry, earthy exhalation, was called "Sulphur." The composition and properties of different metals were explained in terms of their respective proportions of Sulphur and Mercury. Thus quicksilver is runny because it consists almost entirely of the Mercury principle. However, it does not wet the hands, since its small component of Sulphur imparts dryness to its surface. Conversely, iron's high melting point suggests a high Sulphur content.

The proportion and purity of the two principles also determine the quality of the resulting metal. The Mercury and Sulphur in lead are corrupt, imparting a dark colour. Only gold has the optimum proportion of clean Sulphur and Mercury. As evidence for its perfection, gold is able to retain its form: it does not tarnish, and is

[2]The theory is fully discussed by Norris [6]. On some aspects of its medieval reception, see Newman [5, 7].

only with difficulty persuaded to join with other substances (an important exception being quicksilver). The theory also explains why metals are found in different states of purity, depending on the relative proportion of the principles.

This idea has some empirical support. For instance, calxes are made when a "body" (or metal) loses some of its "humidity": the moist quality which makes metals fusible. Calxes are generally not fusible: they have a dry and sometimes brittle appearance, like stone, crystal, or powder. The Sulphur-Mercury theory also helps explain the apparent retrieval of chemical substances following their dissolution in corrosives or compounding with other substances—a reconstitution that made no sense in terms of conventional Aristotelian physics, which stresses that a substance, once it has lost its original form (for instance through dissolution in an acid) cannot readily regain it. As Newman has shown, this explanation allows for an intermediate state between the metals and their most basic building blocks, the four Aristotelian elements (earth, air, fire and water). Rather than being reduced to these elements and losing its form, a metal need only be reduced to its constituent Sulphur and Mercury, principles that may then be recombined to produce the "lost" metal, in a process later described as "reduction to the pristine state" [5].

However, this explanation raised fresh problems. For instance, does each kind of metal have its own specific form, or should differences between metals be viewed merely as superficial variations, or "accidents," of a single, basic, metallic species? Unfortunately, Aristotle had neglected to provide detailed instruction on this matter. The great thirteenth-century Dominican thinker and Aristotelian commentator, Albertus Magnus (1193–1280), therefore undertook to produce his own book on minerals, the *Liber Mineralium*.[3] In it, he argued that each metal had its own specific form; thus, lead was substantially different to gold. On these grounds, Albertus stated his view that alchemical transmutation, although possible, must be very difficult to attain, since it entailed the imposition of a new form—that of gold—upon a different substance [12]:

> And alchemy also proceeds in this way, that is, destroying one substance by removing its specific form, and with the help of what is in the material producing the specific form of another [substance]. And this is because, of all the operations of alchemy, the best is that which begins in the same way as nature, for instance with the cleansing of sulphur by boiling and sublimation, and the cleansing of quicksilver, and the thorough mixing of these with the material of metal; for in these, by their powers, the specific form of every metal is induced.

In setting out this view, Albertus explicitly distanced himself from another position which, he said, was common among alchemists, particularly one "Callisthenes".[4] The alchemists' position, as Albertus characterises it, supposes that one metal can transform into another one through a natural process of digestion and maturation beneath the earth. The least perfect metals gradually ripen into the more

[3]Published in English translation as Albertus Magnus, *Book of Minerals*, translated by Wyckoff [8]. On Albertus' alchemy, see also Partington [9], Kibre [10], and Halleux [11]. A large number of alchemical tracts were later pseudonymously attributed to Albertus.

[4]As Wyckoff notes, this name is a mistake for Khalid ibn Yazid, one of the protagonists of the early *Liber de compositione alchimiae*, and supposed author of the *Liber trium verborum* [13].

perfect ones, even lead eventually becoming gold. Once gold is attained, the process stops, nature having achieved her ends.

This process causes some difficulties for the devout Aristotelian, by implying that the specific form of metal is gold, and that the lesser metals are merely faulty versions of this perfect substance. It also enabled alchemists to argue that, using artificial processes, they could therefore help nature along, but in shorter time [13]:

> For they seem to say that the specific form of gold is the sole form of metals, and that every other metal is incomplete—that is, it is on the way towards the specific form of gold, just as anything incomplete is on the way towards perfection. And for this reason metals which in their material have not the form of gold must be 'diseased'; and [the alchemists] try to find a medicine which they call elixir, by means of which they may remove the diseases of metals… and thus they speak of 'bringing out' the specific form of gold.

Within the overarching Sulphur-Mercury framework, we can therefore identify at least three distinct explanations, or "theoricks," for alchemical transmutation.

First, in his *Book of the Remedy* (sometimes considered to be part of Aristotle's *Meteorology*), the Persian polymath Avicenna argued that each metal belongs to a distinct species, and it is not possible to transmute one species into another. The alchemist would first have to break matter down into its constituent elements, and then reconstruct the new species from scratch—which cannot be done through art.

Second, we have Albertus' position in the *Liber Mineralium*. Albertus interprets Avicenna's "species" differently (and probably not quite accurately), as *specific form* [7]. Each metal has its own specific form, which must be destroyed in order for nature to replace it with a new and better one. If alchemists can find a way of stripping a metal of its original specific form, it may be possible to transmute one metal into another, albeit with great difficulty.

Third is the "maturation" approach that Albertus attributes to Callisthenes. This views all the metals as part of a continuum, within which the less perfect metals are gradually "perfected" until they become gold. By inference, gold is the specific form of all metals. Not only is transmutation possible, but it actually forms part of the natural evolution of metals. Albertus criticises this approach, since the notion of gold as the specific form of metals seems to trouble him.[5]

While each of these theoricks is underdetermined by evidence, they are not without empirical support. For instance, Albertus' theorick of "specific form" can explain why metals are only discovered in discrete species, rather than in a halfway state between metals. It is also broadly consistent with the kind of natural philosophy being discussed in the medieval universities, and hence could be seen as compatible with the "normal science" of thirteenth-century Europe. On the other hand, the "maturation" theorick explains why different ores are often found within

[5]"For there is no reason why the material in any natural thing should be stable in nature, if it were not perfected by a substantial form. But we see that silver is stable, and tin, and likewise other metals; and therefore they seem to be perfected by substantial forms… And as to the experiments which [the alchemists] bring forward, not enough proof is offered." [14].

the same mines—the metals co-exist because they are continually transforming into one another. Interestingly, Albertus himself reports "making long journeys to mining districts, so that [he] could learn by observation the nature of metals" [15].

2.2 Vegetable or Mineral?

As a theory of metallogenesis, Sulphur-Mercury meets some of Kuhn's criteria in terms of accuracy, broad scope, and so forth. As explanations of transmutation, however, the various theoricks derived from it leave a lot to be desired. Each uses ideas about the formation of metals as the basis for arguing whether or not transmutation is possible. They say nothing about how transmutation is to be achieved, except in the vaguest terms—the implication being that the alchemist must somehow replicate and abbreviate a series of processes that would normally occur naturally over thousands of years in the bowels of the earth.

Each explanation also applies only to metallic bodies. Yet to do really interesting chemistry, metals are not enough. For instance, to dissolve metals and their calxes requires solvents made from non-metallic ingredients. *Aqua fortis*, *aqua regia*, and other mineral acids were made using vitriol (commonly regarded as a spirit rather than a metallic body) and salts. Distilled vinegar was of course derived from wine, a "vegetable" product. Other salts were obtained from "animal" substances like hair, urine or eggshells.

Yet, from the perspective of medieval natural philosophy, transmutation is much easier to explain if discussion is confined to the metals and their constituent principles. Alchemical authors are often very critical of reliance on other minerals, including salts, vitriols, and alums, yet are nevertheless forced to recognise their importance. In the words of ps.-Geber [16]:

> Because we see adherence to the bodies accompanied by alteration to occur in no other material but the spirits, we cannot therefore be freed from their use, nor may we escape their preparation by cleaning, which is accomplished by sublimation.[6]

The real ire of alchemists like ps.-Geber, however, was reserved for those who sought to use animal or vegetable ingredients in their work. To scholastic authors it was obvious that, in order to create gold, one must start with some kind of metal. Paradoxically, this argument was supported using an analogy with animal generation: just as man begets man and beast begets beast, so metals may only be generated from metals.

In fact the debate over organic products was not new in the thirteenth-century West. A tenth-century Arabic treatise, the *Mā 'al-waraqī* of Muhammed Ibn Umayl, attacked alchemists who, like the polymath Abu Bakr Muhammad ibn Zakarīyā al-Rāzī ("Rhazes" to the Latins), recommended such animal ingredients as

[6]Note that "bodies" here denote metals; while "spirits" include alums and salts which do not remain fixed in fire.

hair and eggs [17, 18]. Yet these ingredients often produce chemically interesting results. The problem came to a head in the mid-fourteenth century, with the development of an entirely new approach to alchemical transmutation, relying on alcohol as its primary ingredient.

2.3 Inconsistent Results

From the end of the thirteenth century, alchemists embraced an exciting new technology: distillation. Repeated distillation of spirit of wine was found to yield a liquid with peculiar properties: clear as water, yet highly flammable. A drop would burn the tongue. A piece of meat or vegetable matter placed in it would not decay. It could be used as a solvent for oils and other substances that did not dissolve in water.

These qualities led alchemists to infer that the "quintessence of wine" should be able to preserve living human bodies as well as it preserved meat. Unlike mineral acids, it was also a safe solvent for human ingestion. From this arose the notion that quintessence could be used both as an alchemical medicine for internal use and as an ingredient in the transmutation of metals. This theory was set out in great detail in one of the most influential alchemical treatises of the fourteenth century, the *Liber de secretis naturae, seu de quinta essentia* (The Book of the Secrets of Nature, or, concerning the Quintessence), attributed to the Majorcan philosopher Raymond Lull (ca. 1232-ca. 1316).[7] Pseudo-Raymond described the quintessence as a "vegetable mercury," or "resolutive menstruum" [23].

However, although absolute alcohol is indeed effective for extracting plant essences, its effectiveness is limited. In the late fifteenth century, the English alchemist George Ripley rejected quintessence of wine of the kind described by Raymond in the *Liber de secretis*. Apparently on the basis of his own experience, he observed that even multiple distillations fail to produce a quintessence sharp enough to dissolve metallic calxes:

> Some assert that this fire is a water drawn from wine, according to the common way, and should be rectified, being distilled as many times as possible… yet, when water of this kind (which fools call the pure spirit), even if rectified a hundred times, is put upon the calx of whatever body, however well prepared, nevertheless we see it will be found weak and entirely insufficient for the act of dissolving our body with conservation of its form and species. Wherefore it seems there is an error in the choice of this principle, which is called the resolutive menstruum.[8]

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[7] "Raymond" had in fact borrowed the concept, and most of the text, from John of Rupescissa's *Liber de consideratione quintae essentiae* of 1351-52. On John of Rupescissa, see Taylor [19], Multhauf [20], Halleux [21], and DeVun [22].

[8] "Quid*am* autuman*t* igne*m* istu*m* aqua*m* esse | a vino tract*am* vulgari modo rectificariq*ue* debere ea*m* multotie*n*s distillando vt possit | ab ea eius aquosu*m* flegma vires et pote*n*tias sue igneitatis impediens, penitu*s* | extirpari. Sed cu*m* talis aqua centies rectificata qua*m* dicu*n*t fatui sp*iritu*m esse | puru*m* mittitur sup*er* calce*m* corporis optime prep*ar*ata*m*: videm*us* q*uod* ad actu*m* dissolue*n*di | corpus cu*m* co*n*seruaci*o*ne sue forme et speciei impotens ac o*mni*no insufficiens repe*ritur* | Quare videtur q*uod* in electione hui*us* principij quod menstruu*m* resolutiuu*m* di*citur* | error sit" [24]. My

Ripley also knew that Raymond's advice here conflicted with his instructions in another text, in which he recommended the use of mineral rather than vegetable substances: "If, as Raymond says, the resolutive menstruum springs from wine or the tartar thereof, how is what the same philosopher says to be understood: 'Our water is a metalline water, because it is produced from a metalline kind'"?[9]

Ripley would not have phrased the problem in quite these terms, but his basic concern is with the accuracy and consistency of his source. He faced an additional difficulty, namely the fact that an important authority seemed to be contradicting himself. Unknown to Ripley, there was a good reason for this: the many works attributed to Lull were all pseudepigraphic, and written by various authors, presumably engaged in different (although related) types of practice. Fortunately for Ripley, one of these seemed to offer a compromise: it described a solvent made using distilled vinegar, which was more penetrating than the spirit of wine. By dissolving lead salts in the vinegar and then distilling the resulting product, Ripley obtained a solvent that, he believed, was both metalline *and* vegetable in its nature. This substance fulfilled the requirements of all Ripley's sources, preserving Raymond's authority—and, crucially, justifying Ripley's faith in his own observation.

2.4 Conclusion

Medieval alchemists had a difficult task before them, in more ways than one. They had to adjudicate between earlier theories and explanations, because their choice of explanation would often determine the starting matter, processes, and ends of their practice. Since no one had ever witnessed a successful transmutation, they also had to be guided by textual authority to a high degree: resulting in the kind of exegetical shenanigans that have just been seen in the case of George Ripley and the contradictory contents of the pseudo-Lullian corpus.

This still leaves the question of the extent to which practice was genuinely guided by theory. The textual evidence suggests that theories were often amended in light of empirical observations, albeit not in ways that we are used to in the modern world. Rather than replacing the earlier theory, alchemical practitioners had a vested interest in preserving their predecessors' authority. New or revised texts seldom contradicted the revered authority of a past adept. Instead, alchemists preserved the authority of past sources (and demonstrated their own authority in the process), by reinterpreting earlier works in such a way that they gave support to the

(Footnote 8 continued)

transcription and translation. Italics here denote the expansion of abbreviated text. For more detailed discussion of this passage, see [25].

[9]"Sed si a vino oritur menstruu*m* resolutiuu*m* vt vult Ray*mund*u*s* vel a | tartaro ei*us*: quom*od*o intelligitur q*uod* ide*m* p*hilosoph*u*s* dicit. Aqua n*ost*ra est aqua | metallina, quia ex solo genere metallico generatur" [24].

desired findings or approach. Straw men could then be sacrificed in their place: those unsuccessful alchemists, or "fools," who had misunderstood the true meaning of the philosophers.

For alchemists, choice between "theoricks" seems to have been based in part on the compatibility between authority and practice. Authority, however, could still be interpreted in light of practice, while practical programmes might in turn be shaped by the instructions and expectations of authorities. Alchemists did not choose ingredients and processes at random, but allowed their practice to be shaped by the records of their apparently successful predecessors. Yet experience also forced changes, including the adoption of organic substances like vinegar, even when such modifications seemed to conflict with established views.

I have presented this medieval tussle as a case study for an integrated approach to history and philosophy of science. Other than the corpuscular approach championed by William Newman, specific alchemical "theoricks" have received little attention from either philosophers or historians of science. The reasons given by alchemists for selecting one or other approach remain understudied. Yet their complexities and difficulties provide intriguing counter examples to more familiar examples taken from medieval mathematics, astronomy, or optics. Studying alchemical texts will not teach us how to generate gold, except in the most metaphorical sense. It may, however, offer insight into the processes by which pre-modern practitioners devised and used experiments to extend their knowledge of natural processes—a goal that is as much the historians' as the philosophers' stone.

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