Visualization in Medieval Alchemy

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Abstract: This paper explores major trends in visualization of medieval theories of natural and artificial transformation of substances in relation to their philosophical and theological bases. The function of pictorial forms is analyzed in terms of the prevailing conceptions of science and methods of transmitting knowledge. The documents under examination date from the thirteenth to the fifteenth century. In these, pictorial representations include lists and tables, geometrical figures, depictions of furnaces and apparatus, and figurative elements mainly from the vegetable and animal realms. An effort is made to trace the earliest evidence of these differing pictorial types.

Keywords: *visualization in alchemy*, *science and craft*, *transformation*, *analogy*, *metaphor*.

1. Introduction

Visualization in medieval alchemy is a relatively late phenomenon. Documents dating from the introduction of alchemy into the Latin West around 1140 up to the mid-thirteenth century are almost devoid of pictorial elements.[1] During the next century and a half, the primary mode of representation remained linguistic and propositional; pictorial forms developed neither rapidly nor in any continuous way. This state of affairs changed in the early fifteenth century when illustrations no longer merely punctuated alchemical texts but were organized into whole series and into synthetic pictorial representations of the principles governing the discipline. The rapidly growing number of illustrations made texts recede to the point where they were reduced to picture labels, as is the case with the *Scrowle* by the very successful alchemist George Ripley (d. about 1490). The *Silent Book* (*Mutus Liber*, La Rochelle, 1677) is entirely composed of pictures. However, medieval alchemical literature was not monolithic. Differing literary genres and types of illustrations coexisted, and texts dealing with the transformation of metals and other substances were indebted to diverging philosophical traditions. Therefore, rather than attempting to establish an exhaustive inventory of visual

HYLE – International Journal for Philosophy of Chemistry, Vol. 9 (2003), No. 2, 131-170.

forms in medieval alchemy or a premature synthesis, the purpose of this article is to sketch major trends in visualization and to exemplify them by their earliest appearance so far known.

The notion of visualization includes a large spectrum of possible pictorial forms, both verbal and non-verbal. On the level of verbal expression, all derivations from discursive language may be considered to fall into the category of pictorial representation insofar as the setting apart of groups of linguistic signs corresponds to a specific intention at formalization. The main form of these are lists and tables which may or may not be combined with linear, diagrammatic constructs. Occasionally, discursive language is also used to construe figures or parts of figures and sometimes they include portions of texts (Figures 1 & 2).

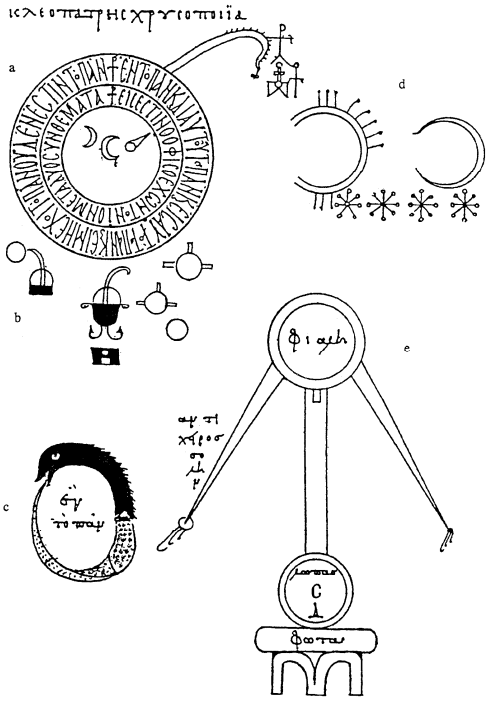


Figure 1: Venise, Biblioteca nazionale Marciana, ms. gr. 299, fol. 188v (tenth to eleventh century). Zosimos of Panopolis, *Authentic Memoirs*, V (ca. 300). Symbols of cosmic principles, of substances and illustration of apparatus.

Whether they are composed of words or of lines, the basic forms of diagrammatic figures of alchemical documents are rectangular and circular.

When used independently of specific philosophical systems, the rectangular or square forms tend to be neutral from a semantic point of view, while the circular form is invested with an intrinsic mimetic dimension in relation to fundamental cosmological systems. In the Platonic and neo-Platonic philosophical and theological traditions it expresses perfection; in the Aristotelian context of natural philosophy it refers to cyclical processes within the spherical cosmos. Figurative representations, anthropomorphic or non-anthropomorphic, may be added subsequently just as they may stand alone and form complete scenes.

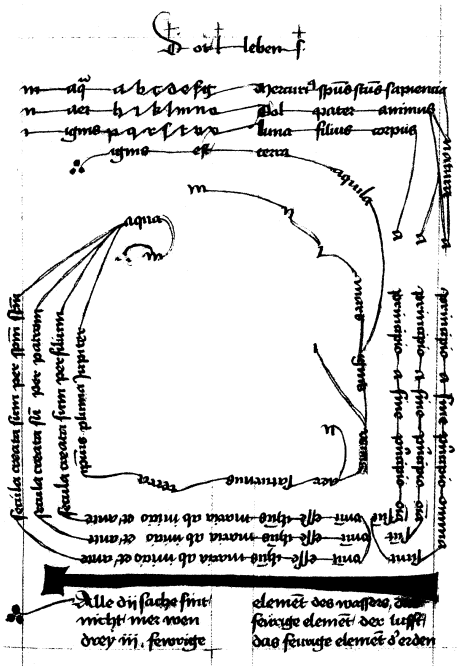


Figure 2: Nürnberg, Germanisches Nationalmuseum, ms. 80 061, p. 158 (ca 1420). *Book of the Holy Trinity*. Letter symbolism designating metals and alchemical operations (following Ganzenmüller, 1939, p. 117).

In connexion with alchemical texts, pictorial representation relates either to observable or to unobservable objects and processes, and to conceptual schemes. The category of visible and observable things comprises, above all, apparatus, furnaces and vessels, characteristics of substances, and stages of transformation. While furnaces and vessels are depicted by direct imitation, observable characteristics and their alterations are visualized either diagram-

matically or by way of similes previously developed on the discursive level. The category of the invisible and unobservable includes the so-called occult or hidden qualities of substances and change of qualities supposed to be either latent and interior to a given substance or subterranean. Above all, it comprises that of substantial change, which was understood, following Aristotle, as the passage from generation to corruption and vice versa (Ganzenmüller 1939) . All of these are also visualized by diagrammatic figures and by verbal similes that have been transposed onto the pictorial level. In this case, tables and more elaborate diagrammatic figures tend to relate categories of the visible to categories of the invisible, for instance lists of observable celestial data to processes of subterranean natural generation and to the transformation of substances produced by human art. As to conceptual schemes, they are visualized, above all, by geometrical figures and by diagrams to which may be added personifications and other figurative elements, and which occasionally develop into figurative representations.

Verbal and pictorial similes in alchemical documents may be divided into two main groups: analogies, on the one hand, and diverse rhetorical forms of figurative speech – allegory, metaphor, enigma – on the other. While the basic function of analogies is to help finding unknown terms and to name them, the other category of similes relates to persuasion, clarification, and simple comparison. This division, however, merely indicates major tendencies. Hybrid forms are frequent and even the rule as literary genres of alchemical writings diversify in the later Middle Ages. Moreover, similes taken from the macrocosmic, microcosmic, animal, and vegetal realms do not only have a heuristic function but they are also intended to conceal and to mislead. Following a recurrent complaint, the ensuing confusion was one of the many problems alchemists encountered when choosing the ingredients for their work. Indeed, from its very beginnings in Alexandrian Egypt, alchemy was the only scientific discipline to systematically resort to similes.

However, the use of symbolic signs, which were an integral part of Greek alchemical documents[2] (Figure 1), remained sporadic in the Latin West between the twelfth and fifteenth centuries. One of the few instances of symbolic notation for metals, which were partly derived from planetary pictograms as well as for sulphur and arsenic, occurs in a late thirteenth-century copy of (pseudo) Albertus Magnus, *De alchimia* (also entitled *Semita recta*).[3] And in the early fifteenth century the richly illustrated *Book of the Holy Trinity* used, besides planetary symbols, diverse signs similar to those found in magical texts, such as configurations made of dots and small circles, the swastika, and also letters from the alphabet.[4]

The presence of pictorial forms in medieval alchemy raises, above all, the problem of their function in medieval scientific texts as well as in texts that deviate from contemporary criteria of scientificity. Medieval alchemy defined

itself as *scientia* and as *ars*. That is, alchemy was not merely a contemplative discipline – the proper concern of ancient and medieval science –, but it was also aimed at efficiency, at bringing about change in the realm of corporeal substances. Its operations resulted in innovations – especially in the era of distillation products – in need of explanation. Accordingly, medieval alchemy made a continuous, always renewed effort to become part of an universally approved and institutionally transmitted cosmological system. But although is was occasionally acknowledged as a science, its scientific status was frequently put into question and even denied, it being considered either a mere craft or the activity of charlatans. Indeed, the problems alchemists encountered highlight a specific medieval reality, namely the gulf between science and the crafts. While science was considered to be an intellectual, rational activity based on true principles, crafts were defined as being based merely on empirically acquired knowledge, on experience. Thus, due to its claim to adopt scientific principles as guidelines for operating, alchemy deviated from standard conceptions of science, just as it stood in sharp contrast to most medieval crafts. Not only did the elaboration and the transmission of its general theories of natural and artificial formation and transformation of substances hinge on literacy, but even the knowledge of its recipes was ultimately based on the written word.

Despite the fact that medieval alchemy defined itself as a science, it cannot be termed 'chemistry', nor can it be considered to represent a stage in the history of chemistry and of experimental science. Its general theories of natural and artificial formation of substances were cast in terms of the prevailing Aristotelian and neo-Platonic philosophical frameworks. As long as the conception of the universe as an organic whole prevailed, its dismembering and the experimental reproduction of natural mechanisms were neither thinkable nor realizable.[5] Despite multiple attempts at all-embracing explanations of substantial change, natural and artificial, as well as at systematization of operational procedures, theory remained divorced from experimental data. Despite its claim to universality through unifying theory and widely circulating texts, particularism prevailed in alchemy in the same way it did in all traditional crafts of pre-industrial societies due to specific local working traditions, vocabulary, and the practice of secrecy. Lastly, minerals, metals, salts, and other substances used by alchemists varied widely from one geographical area to another in terms of composition and impurities.

On the grounds of these considerations, the analysis of visualization will be based on a historical evaluation of alchemy following the then prevailing philosophical and theological conceptions. Reasons for the absence or presence of pictorial forms is best evaluated with respect to contemporary criteria of scientificity and forms of conveying knowledge, and to the corresponding epistemological issues.

2. Alchemy as *scientia naturalis* and *ars*: the analogical argument and visualization

In Arabic classifications of science and philosophy, which were adapted in the twelfth century, alchemy was defined as a sub-branch of natural philosophy (*scientia naturalis*), sharing this definition, above all, with medicine. Thus, about ten years after the first translation of an alchemical text into Latin (Morienus, *De compositione alchimie*), Dominic Gundissalinus described alchemy as belonging to physics in his *De divisione philosophiae* (ca. 1150).[6] It was a science and an art aimed at the transformation of species.[7]

Subsequently, by the mid-thirteenth century, Aristotelian philosophy of nature had become the framework for all physical studies in medieval universities. And, since at that time the general attitude was rather favorable toward the *teknai*, discussions of the artificial production of metals and other mineral substances took place in the context of the study of Aristotle's *Meteorologica*. Together with its frequently unacknowledged Avicennian appendix on the formation of metals and minerals (also transmitted under the title *De congelatione et conglutinatione lapidum*),[8] the *Meteorologica* served, from 1200 onward, as a theoretical basis for the alchemist's manipulation of substances.

In order to integrate alchemy into generally accepted theories of *scientia naturalis* (or *physica*), use was made of an analogical argument, analogy being understood in the sense of a principle of scientific explanation where, as Shmuel Sambursky put it, "one phenomenon is explained in terms of the functioning of another we are acquainted with or have got used to".[9] The argument links three levels: the level of general cosmologic theories, the level of particular areas and substances, and the level of art imitating macrocosmic processes.[10]

(1) The overall cosmological level was cast in Aristotelian categories of qualitative physics and its neo-Platonic elaborations.[11] Aristotle explained change in the sub-lunar, corporeal part of the world in terms of the cyclical association and dissociation of two pairs of opposites, the cold and the hot, the wet and the dry. From this process result the elemental constituents of fire, air, water, and earth. The annual local movement of the sun is the cause of the continuous change of one element into another and of all natural cycles of generation and corruption.[12] As to the neo-Platonic philosophical tradition in its Western form, it allowed, above all, to introduce the sphere of the divine; in its diverse Arabic elaborations, it helped account for a more diversified celestial influence made in terms of astrology and of celestial virtues.

(2) The general theory of the natural formation of subterranean substances was based on Aristotle's final part of the third book of the *Meteorologica* where the Philosopher puts forward that metals are formed from compressed humid exhalations, and on the fourth book where the active, formative principle of metals is said to be the cold.[13] The more specific theory of the genera-

tion of metals in terms of their basic material and formal constituents, namely quicksilver and sulphur, was set out in Avicenna's *De congelatione et conglutinatione lapidum*. Here, the active, formative principle was supposed to be heat, the duration and intensity of coction being responsible for the differentiation among metals.

(3) The relation between nature and art was conceived in Aristotelian terms of *mimesis*: art imitates and completes but never replaces nature. The idea of the inferiority of art (*ars*) was intrinsically linked to the conception of nature as an organic whole and of nature as an intelligent artisan. As an artisan, nature induces movement internally, thereby producing essential change, namely generation. By imitating nature, the human artist merely brings about external, 'mechanical' change while the substance remains identical.[14]

In principle, the Aristotelian physical system prevailed in medieval natural philosophy. Nevertheless, Platonic and neo-Platonic philosophical positions were adopted by major thirteenth-century philosophers, and alchemical texts usually combine these differing philosophical traditions.

In the Aristotelian physical tradition, analogies function in relation to identical causal schemes; either nature or the human artisan induces movement in the sense of qualitative change.[15] Thus Aristotle explained the formation of the foetus by analogical inference from the art of cooking: it is a kind of coction due to the action of heat deriving from sperm.[16] Adopting the Aristotelian scientific method, Albert the Great (d. 1280) gave, in his mid-thirteenth-century *Mineralogy*, an account of the natural formation of metals and minerals by analogy from the cooking of the alchemists – in his estimation the best imitators of nature – and from current scholastic medical theories on the formation of the foetus.[17]

Those major thirteenth and fourteenth-century alchemical texts that were concerned with establishing a physical theory – in the sense of *scientia naturalis* –, or at least with transmitting it, reversed the analogical relation: alchemical theory and practice were based on the model of natural macrocosmic and microcosmic processes. Artificial generation of metals and minerals was, among others, explained with reference to the biological model of animal (human) generation. In these, the rhetorical use of similes for the purpose of either clarifying and illustrating abstract principles or for avoiding to name certain substances and procedures are absent or at the best very limited. As pointed out by Albert the Great with respect to those alchemical writings which do not conform to the scholastic Aristotelian concept of science, they conceal their meaning in metaphorical language, "which has never been the custom in philosophy".[18]

In Platonic and neo-Platonic theories of knowledge, the analogical argument hinges on the assumption of an essential link between the intelligible model and its visible copy, between intelligible realities and mental con-

structs. The corporeal world is thought of as a visible (and tangible) manifestation of intelligible mathematical patterns and in particular of the spherical form, the most perfect one. Due to the divine part of his mind, the human artist is able to apprehend and to reproduce these patterns.[19] The divine – divinity and the cosmos in its divine dimension – and things of great spirituality were thought of as being beyond comprehension and as being conceivable only with the help of corporeal similes. Thus, in both the Platonic and neo-Platonic medieval philosophical traditions, similes – verbal or pictorial – were considered essential to help conceive and to represent first principles.

Pictorial forms occur in Aristotelian and in Platonically or neo-Platonically oriented thirteenth-century and subsequent discussions of the natural formation and artificial production of metals. However, while figures were rarely used in the context of Aristotelian natural philosophy, things were different with Platonic cosmology. Here their function was intrinsically linked to the physical system, since Plato had conceived of the elementary parts of the world in terms of geometrical configurations.

In thirteenth-century Aristotelian natural philosophy are to be found some instances of the use of geometrical figures. Yet, just as Aristotle himself did not make frequent use of geometrical demonstration, his medieval followers never developed it into a widely used method of proof in either medieval Aristotelian natural philosophy or alchemy. As far as the classification of sciences goes, Albert the Great, for instance, rejected Plato's subordination of physics to mathematics and to divine realities: the physicist may prove things geometrically, but by doing so he merely establishes the fact (*quia*), not the reason for the fact (*propter quid*).[20]

In order to conceive of the natural formation of metals and also to explain it, Albert the Great himself made use of two figures in his *Mineralogy* (1250-1252),[21] the one work that established a theory of mineral and metal formation then deemed worthy of Aristotle. Both occur in a context of analogical inference from the visible procedures of human art to the invisible workings of nature. Being the best imitators of nature, alchemists construe vessels which reduplicate natural conditions under which metals are generated (Figure 3):[22]

> When they [the alchemists] wish to make the elixir which is to have the color and tincture of gold, first they take a lower vessel big enough to hold the materials of well-purified sulphur and quicksilver or other things which they put into the elixir. Next they arrange it so that on the top of this there may be a vessel having a long, narrow neck; and over the opening of this neck is a cover of clay in which is a very small, narrow opening […] The better operators make the vessels of glass; and the character of the first vessel is like a urinal, and the second stands on top of it and receives all the vapour which rises from it. And the contact of the two glasses or vessels is well sealed with lute so that nothing can escape […] The figure of the vessel is like this: the lower vessel is *a b c d*, the upper vessel *e f g*, and the cover *h*. It will be the same in nature.

Albert used another geometrical figure marked by letters when setting forth his theory of metal formation in different places in the ground, porous or non-porous. According to Albert, vapor mixed with earthy parts penetrates into the pores of the earth before solidifying into a metal, which he exemplifies by pouring liquid metal onto the ground. He then gives instructions for drawing a circle *a b c* which is to represent the metal spread on the ground; two lines, *c d* and *a g*, represent the way the metal penetrates into the earth, namely through veins. This type of geometrical demonstration follows Aristotle's method for proving the sphericity of the elemental layers of the world.[23]

Figure 3: London, British Library, ms. Ashmole 1471, fol. 33v (fourteenth century) (from Albertus Magnus 1967, plate II). The lower vessel *a b c d*, the upper vessel *e f g* and the cover *h* reduplicate natural, subterranean conditions under which metals are generated.

In the thirteenth century, representatives of Platonically-oriented cosmology and natural science such as Robert Grosseteste (1175-1253) defended a systematic use of geometrical representation. Following Grosseteste, "all causes of natural effects must be expressed by means of lines, angles, and figures, for otherwise it is impossible to grasp their explanation".[24] The corresponding theory of knowledge was neo-Platonic and Augustinian. The intelligible order underlying the physical, corporeal world was thought to be apprehensible by the divine part of the soul, by the 'eye of the soul', and geometrical figures (as well as number patterns) were used as 'ladders' leading to eternal truths.

In this respect, John Scottus Eriugena's ninth-century *Periphyseon* exercised considerable influence on thirteenth-century philosophers such as, above all, Ramon Lull (about 1232-1315) and on the authors of the pseudo-Lullian fourteenth-century alchemical corpus. In order to explain first causes and their progression into multiplicity, the teacher of Eriugena's dialogue makes use of a "visible and corporeal figure", namely of a circle with lines radiating from its centre to the circumference. Learning "outwardly by sense" and apprehending on geometrical grounds is being both opposed and paralleled with "understanding inwardly, by

imagination". In one way or another, geometrical figures were mental constructs made for the purpose of meditation and contemplation, but without being in a mimetic relation to anything.[25] Thus, adopting this kind of theory of knowledge did not necessarily imply that of Platonic cosmology with its geometric elementary shapes, which do reflect pre-existing patterns. From the thirteenth century on, the combination of Aristotelian physical principles with neo-Platonic epistemology was quite common in alchemical texts. But only very few instances are to be found where geometrical figures are used in terms of the *Timaean* theory of elementary shapes.[26]

In alchemy, the earliest so-far known Western document to use pictorial forms in a neo-Platonically oriented epistemological context is the *Book of the Secrets of Alchemy* compiled in 1257 by a student of medicine, Constantine of Pisa.[27] The corresponding theory of knowledge is set forth in a few *topoi*. Concerning the etymology of the letter 'L', the author notes: "According to etymology, it ['L'] is so called from *lucidando* and from *illuminando*; illuminando, *i.e.* making clear that which is obscure, and throwing a greater light on that which is intelligible [...] for the intellect is the eye of the mind".[28] Being "beyond understanding", God and his eternity can be grasped neither "by reason nor by working".[29]

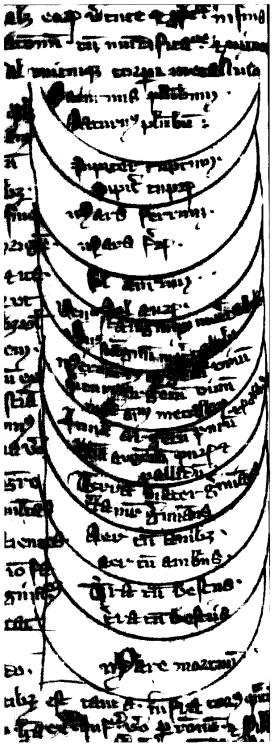


Figure 4: Glasgow, University Library, ms. Ferg. 104, fol. 45v (1361). Constantine of Pisa, *The Book of the Secrets of Alchemy*. The creation of metals.

Essentially a set of lecture notes, this document gives precious insight into current mid-thirteenth discussion on natural formation of metals and it sheds light on the effort to deal both verbally and pictorially with alchemy as a novel discipline. On the level of cosmology, it juxtaposes the physical theory of Aristotle's *Meteorology* and its Avicennian prolongation with Platonic and neo-Platonic traditions. More specifically, Constantine – or rather his unknown teacher – tried to provide alchemy with not only a physical but also a theological basis. The overall cosmological model is still that of the Biblical creation in its Platonically oriented twelfth-century interpretation. In order to achieve this particular goal, use was made of

an analogical argument and of corresponding figures, above all, of what may be called the 'creation diagram'.

With respect to the creation of metals, the argument is that God brought forth the six metals within the six days of creation by differentiating homeomerous bodies.[30] The corresponding diagram is composed of a vertically laid-out sequence of seven circle segments bearing the names of the planets and their corresponding metals. At the bottom the series is terminated by segments with inscriptions naming earth, air, and the Dead Sea (Figure 4). In a Flemish fourteenth-century versified adaptation of this document (*The Book of the Secrets of My Lady Alchemy*), the 'creation diagram' has been considerably developed through additions and modifications. At the top is added a circle enclosing the hand of the creator; below, personifications (heads) of the planets and of the earth; and the circle segments that refer to the sublunary world contain birds, land-animals, fish and a mask as the origin of waters. In both instances, the arrangement of semi-circular and circular segments of the diagrammatic structure is determined by the hexaemeral leitmotif "*In principio creavit Deus celum et terram*". This is made explicit in the more developed figure where the divine creator and ordinator is named and symbolized at the top of the series (Figure 5).[31]

Following this, the motif of the Platonic Biblical Divine Artisan, who brings order into previously created matter, is interpreted in terms of alchemical operation and the separation of the four elements out of chaos, which serves as an analogous model for the solidification of quicksilver brought about by the alchemist. Here, the alchemist does not imitate the art of nature but the art of divinity:[32]

> All strength and operation rest upon mercury, it being the mother and matter of all metals, just as *hyle* is the first cause […] the material cause comes about through congealing as in the first *hyle*, the mother of all creatures, as established by the Supreme Artisan […] And just as primordial matter was intermingled and without form, so it is with the congelation of mercury, which is like thick water, fluid and invisible. And just as it is told of the Spirit of the Lord moving upon the waters as the first cause, so this work consists of twelve waters […].

In the *Book of the Secrets of Alchemy*, astrology plays a major role in helping understand alchemy as a science and also in guiding its operations. The corresponding tables serve as a tool for causally relating heavenly phenomena to natural generation and to artificial transformation of metals; they also help establish analogical relations between the visible and the invisible. As is the case with the other figures of this text, their specific function is made explicit. A first set of astrological tables depict the physical theory in its astrological extension according to which not only the sun but also the other planets cause generation in the sub-lunar realm. The respective tables are announced

thus: "It is necessary to know the order of the planets with respect to homomereous things, *i.e.* metals, as given in this table […]."[33] "In order, therefore, to gain knowledge of the science, one must understand the motion of the upper bodies with respect to homomereous bodies by means of this table, called the House of the planets, as they are in their signs"[34] (Figure 6).

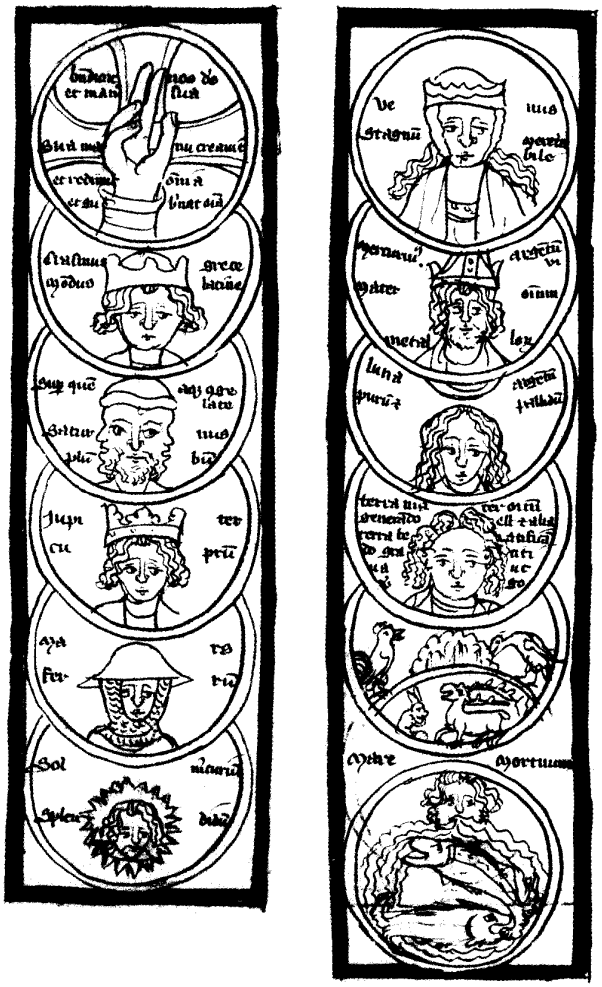


Figure 5: Wien, Österreichische Nationalbibliothek, ms. 2372, fol. 46vb-47ra (second half of the fourteenth century). *The Secrets of My Lady Alchemy* (Adaptation of Constantine of Pisa, *The Book of the Secrets of Alchemy*). The creation of metals.

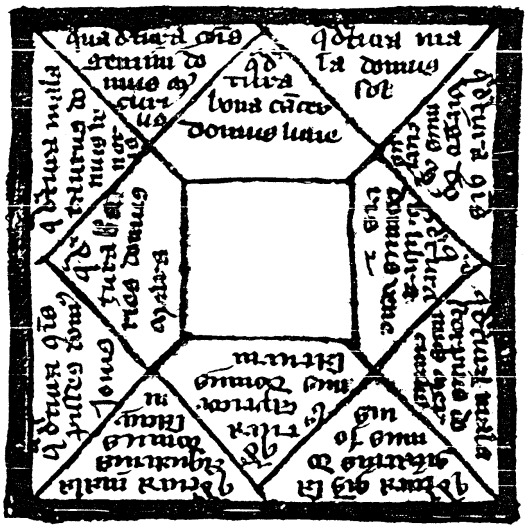


Figure 6: Wien, Österreichische Nationalbibliothek, ms. 2372, fol. 35r (second half of the fourteenth century). *The Secrets of My Lady Alchemy* (Adaptation of Constantine of Pisa, *The Book of the Secrets of Alchemy*). Table listing the qualities common to planets and to metals.

Two further astrological tables which serve as guides to the operating alchemist are part of the following argument:

> Congealing, according to Aristotle, is the uniting of parts that can be liquefied, or the thickening of parts that are liable to be fluid. And it is as impossible to lick heaven with one's tongue as it is impossible to enter upon the practice of alchemy other than through the congealing of mercury, of which many are ignorant and which cannot be taught reliably except through the motion of the upper bodies, especially the orbit of the moon, as first shown in this table.[35]

> Good and bad lunations, or effects, can be seen in the preceding table; here and now, the following table will give abundant information about good and bad quarters and their corresponding effects.[36]

To conclude the discussion of the selected figures of the *Book of the Secrets of alchemy*, it may be stated that their general function is to enhance the analogical argument of the text in relation to theological, ontological, and physical conceptual schemes. Both the 'creation diagram' and astrological charts are construed on the principle of visual substitution: older pictorial forms are altered to express theories of the formation and transformation of metals, as well as to give instruction for the alchemist's operations. Astrological tables

traditionally used in a medical context for listing the moon-microcosm correspondences have become invested with the names of metals. Likewise, in the 'creation diagram' references to stellar causality and metals are inserted into the combined pictorial schemes of Genesis illustrations and of the elementary and stellar orbits that have been reduced to segments spread out in a row.[37] In the vernacular fourteenth-century version of the *Book of the Secrets of Alchemy* (*The Book of My Lady Alchemy*), figurative elements such as the hand of God and personifications of planets are added to the basic structure of circle segments.

3. The observation of accidental qualities: visualization and metaphor

Albert the Great's and Constantine's treatises represent the few thirteenth-century documents to include figures visualizing conceptual schemes relating to the natural formation and to the divine creation of metals. Subsequently, within the all-pervasive system of Aristotelian natural philosophy, emphasis was laid on observable accidental qualities. However, despite the recurrent urge to view the characteristics and behavior of substances, the transition to their pictorial representation took place merely in alchemical documents dating from the second half of the fourteenth century. Moreover, these observable characteristics and stages of transformation were visualized by transposition of verbal metaphors onto the pictorial level, 'metaphor' being understood in its classical Quintilian definition as *alieniloquium*. Thus, although the conceptual basis for putting observational data to the fore was thoroughly Aristotelian, visualization of these by way of metaphors did not agree with the standards of the scholastic scientific method and its syllogistically conduced arguments. It should be noted that not only authors and compilers of derivative literary products favored the use of similes for comparison and for didactic purposes, but that in the 1330s even a scholastically trained theoretician like Petrus Bonus justified and recommended the use metaphorical language in alchemical writings.[38]

The scholastic Aristotelian method adopted by all major alchemical treatises from the mid-thirteenth century on was that of combined deduction from general principles and induction based on sense data, that is, on the observation of accidental qualities of substances. In metals, these were, in Albert the Great's words, "their being liquefiable and malleable, their colors, tastes and odors and their ability to be consumed by fire".[39] In his *Mineralogy*, Albert explains that[40]

> When dealing with many particulars we must first understand the natures from the signs and effects [observed] [*ex signis et effectibus*] and proceed from these signs to their causes and compositions; for the end effects are more obvious to us. But in dealing with the nature of universals […] we have to proceed in the opposite way, [reasoning] from the cause to the effects and powers and signs.

Examples from the *Mineralogy* for reasoning in terms of experience and signs are:[41]

> The production of metals is cyclical, from each other. Experience shows that this is the case [*probat autem hoc experta*], both in the operations of nature and in the techniques of art. As to natural processes, I have learned, by what I have seen with my own eyes [*visu proprio didici*], that a vein flowing from a single source was in one part pure gold, and in another silver having a stony *calx* mixed with it […].

Elsewhere, Albert states that[42]

> iron is subject to rust, the cause of this being that it contains burnt earth; for what putrefaction is to moist things, rust is to iron. For when the moisture is removed, what is left behind is parched, dry, and burnt, and is reduced to ashes. Evidence [*signum*] of this is that iron is especially affected by rust if something burning is thrown upon it – such as salt, sulphur orpiment, and the like.

Albert's *Mineralogy* set the standards for a rich tradition of alchemical writings in which expressions such as 'to see with one's own eyes', 'observation', 'signs', 'experimental evidence' and 'experience' were extensively used.[43] On a theoretical level, reference to observational data, *experimenta*, helped confirm previously reached conclusions.

The main document of this tradition was alternately entitled *Semita recta* and *De alchimia*. In this widely read and often varied-upon pseudo-Albertian treatise, the expression 'I have seen' (*vidi*) is systematically used in theoretical discussions, as the following instances illustrate.[44]

> We see different species receive different forms at different times; this is evident by decoction, and constant contact: what is red in arsenic will become black and then will become white by sublimation […] If, by any chance, someone should say that such species can easily be transmuted from color to color, but that in metals it is impossible, I will reply by citing the evident cause through evident indications and proofs […] For we see that azure […] is produced from silver […] We see, furthermore, that copper receives a yellow color from calamine stone […].

Alchemical treatises that adopted the Aristotelian scientific method all agree that observation leads nowhere unless it be guided by the knowledge of principles, divine or natural. The pseudo-Lullian fourteenth-century *Codicillus*, for instance, asserts that[45]

> The art is nothing unless the artisan starts out with certain and determinate principles; and he must regulate himself on demonstrative signs, namely the colors which appear in the process of working.

Roger Bacon's theory of experimental science also exercised considerable influence on alchemical texts, especially on the fourteenth-century pseudo-Lullian alchemical corpus where one finds expressions, such as "*sicut ostendit ratio naturalis et experientia nobis certificat*", as has recently been shown by Michela Pereira.[46] Given the impact of this scientific tradition the main points of Bacon's theory may be recalled in his own words.[47]

> There are two modes of acquiring knowledge, namely, by reasoning and experience. Reasoning draws a conclusion and makes us grant the conclusion but does not make the conclusion certain […].

Bacon exemplifies his assertion that "authors write many statements and people believe them through reasoning which they formulate without experience" with a reference to the belief that diamonds cannot be broken except by goat's blood:

> But fracture by means of blood of this kind has never been verified […] and without that blood it can be broken easily. For I have seen this with my own eyes, and this is necessary, because gems cannot be carved except by fragments of this stone […] Therefore, all things must be verified by experience.

On the level of alchemical operation which were exposed in sections concerned with *practica*, the main accidental qualities of substances to be observed were colors. Their appearance and disappearance increasingly helped mark stages of transformation and the number four was to become canonical in fourteenth-century alchemical texts such as the pseudo-Lullian *Codicillus*.[48] In a *Rosarius* attributed to John Dastin (first half of the fourteenth century), the author writes:[49]

> There are four principal colors: black, white, yellow, and red […] Colors will then teach you how to handle fire, for they show how long and when the first, the second, and the third fire are to be made. Thence, if you are a conscientious workman, colors will teach you what to do.

Here it is stressed that the alchemical process is to be performed entirely in one vessel of thick hermetically sealed glass so that the operator may observe the changes.[50]

In alchemical treatises where scholastic Aristotelian principles of natural philosophy prevailed, the first step toward visualization was made in relation to instructions for construing apparatus, furnaces, and vessels. These are given in those sections of thirteenth-century treatises that are concerned with *practica*, with instructions for operating and recipes. Frequently the *practica* is preceded by a *theorica*, but practical instructions alone were also circulated.

The major alchemical document of the thirteenth-century scholastic Aristotelian alchemical literature, the *Summa perfectionis magisterii* of (pseudo)-Geber,[51] systematically describes apparatus used in diverse alchemical operations (*sublimation, descension, distillation, calcination, solving, coagulation, fixation, ceration*). However, the text does not yet refer to figures. In the oldest manuscripts of the *Summa*, these are drawn in the margins, as is the case with the late thirteenth-century copy bearing the title *Summa collectionis complementi occulte secretorum nature* (Bibliothèque nationale de France ms. lat. 6514, fol. 68r-71r). The fourteen figures of this manuscript copy were first analysed and reproduced by Marcellin Berthelot[52] (Figure 7). A contemporary Paris manuscript includes a *Practica* of Alchemy by Jacob the German (*Practica alchimiae Jacobi Theutonici, quod ipse operatus est*). Eleven marginal figures accompany the text where instructions for fabricating apparatus alternate with recipes (fol. 139r-141v). That is, whenever a specific vessel is necessary for a given operation, Jacob the German includes instructions for its construction. But again, in the text the author does not refer to figures.[53]

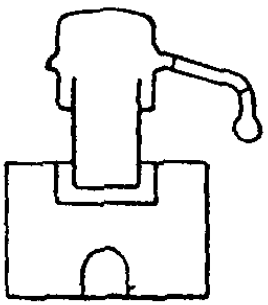


Figure 7: Paris, Bibliothèque nationale de France, ms. lat. 6514, fol. 70r (end of the thirteenth century) (Berthelot 1893 [reimpr., 1967], vol. 1, p. 151, fig. IV). An alembic.

Reference to figures of furnaces and vessels are to be found in the pseudo-Albertian *De alchimia* or *Semita recta* that circulated in the second half of the thirteenth century and enjoyed an enormous success, whence it was subjected to many variations. Here, descriptions of apparatus are concluded by calling the reader's attention to accompanying figures: "And this is the plan for the furnace" (*Et haec est forma furni*).[54] Concerning the distillation oven, the text reads:[55]

> Distillation ovens are to be made in the following way: they are construed like those [described] above, of clay […] the oven should be wider at the top than at the bottom, as this figure shows.

Two folios of a manuscript of the *Semita recta* now in Glasgow (University Library, ms. Hunt. 110, fol. 27r-35v, fourteenth century) [56] may serve as an example for the relation between descriptions and drawings of vessels and furnaces. On folio 33r there is a description of a pot (*olla*) covered by a lid, which is provided with a narrow neck into which a stick is introduced. The corresponding illustration is in the margin. Next is another pot with a narrow neck, announced in the same way as the preceding figure by the formula

"*cuius hec est figura*". The small drawing follows in the text itself (fol. 33r). It depicts the lower part of one of the most frequently used vessels for *distillatio per descensum*.[57] Mercury has to be poured into this vessel. The description of the furnace to be used for this operation follows: "Then take a round furnace […] with an opening for the vessel and for the fire, this being its figure [*cuius hec est figura*]. Heat this furnace to redness",[58] and so on (Figure 8).

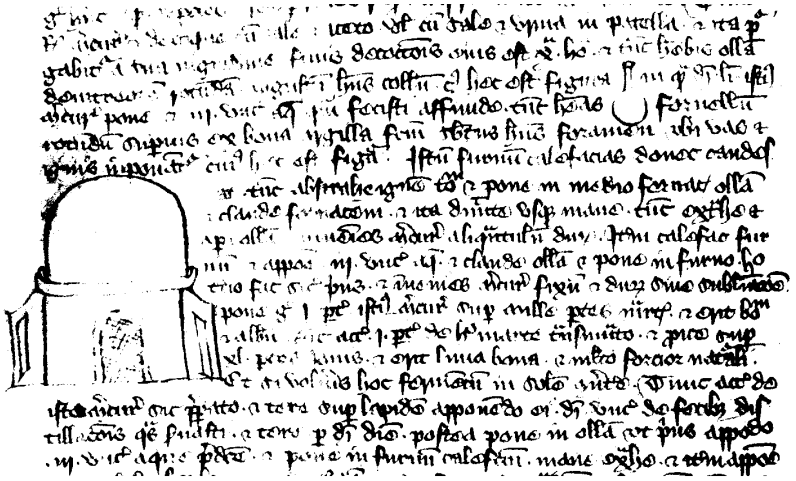


Figure 8: Glasgow, University Library, ms. Hunt. 110, fol. 27r-35v; fol. 33v (fourteenth century). *Semita recta domini Alberti*. Drawings of vessels and a furnace.

The first depictions of diverse processes and stages of transformation in glass vessels are included in a highly original vernacular verse from the region of the lower Rhine, possibly Brabant, dating from the second half of the fourteenth century. The author of this text without title identifies himself as Gratheus.[59] He was obviously a craftsman and aimed at a popular public without knowledge of Latin.[60] The absence of philosophic discussion of transmutation is counter-balanced by a theme that should become increasingly important toward the end of the Middle Ages and in the sixteenth-century: bookish learning and textual parables lead to errors.[61] In order to avoid these, Gratheus recommends reading the book of heaven, a "manifest mirror and examplar of alchemy".[62] There, one may perceive with one's own eyes the whole work of alchemy and all types of vessels.[63] This argument applies and old exegetical topos to alchemy. As pointed out by Augustine, the book of nature may be read even by the illiterate (*idiota*).

Emphasis is laid on technical aspects of the work, the fabrication of vessels appropriate for different operations and of apparatus such as an oil press

made of steel (*stal*) and wood.[64] In the first part of the treatise a wide range of differing vessels are described and depicted. Instructions for their fabrication are interspersed with recipes. Artificially created names for vessels (*bima*, *alpha*, *fumera*, *etc.*) clearly have a mnemonic function, and the same applies to stars and their unusual depictions (some hundred and fifty stars are provided with faces), which play a major role in the text. The author heavily insists on the pedagogical function of figures: "I wish to teach you the vessels which are useful to work with by way of figures".[65]

Figure 9: Wien, Österreichische Nationalbibliothek, cod. Vind. 2372, fol. 59 ra (second half of the fourteenth century) (Birkhan 1992, vol. II, fig. p. 66). Gratheus, *Introduction to Alchemy*. Ylarius, Multipos and Virgo in the glass vessel named 'samimas'.

The description of alchemical transformation is cast in terms of personified roles acting in violent amorous and wary dramas. At that point a literary tradition of alchemical texts comes in that differs widely from those of mainstream scholastic alchemical texts in that the ultimate philosophical background is an amalgam of pre-Socratic and Gnostic traditions. Gratheus assimilated particularly allegorical alchemical texts of Greek and Arabic origin, such as Zosimos' *Dream Vision*, where personifications of metals are dis-

membered;[66] and Ibn Umail's *Tabula chemica*, which describes the courtship and the wedding of the sun and moon[67] and which had an enormous impact on late medieval alchemy. In the fourteenth-century document, these are the main *dramatis personae* appearing as king and queen and named Ylarius and Virgo. One of the many actors, a figure provided with a stick and called Multipos, molests and separates them in a vessel called "*samimas*".[68] The corresponding illustration (see Figure 9) is introduced by the following line: "Multipos it is named [and] should you wish to know, this is his [*Multipos*'] aspect [*tekin*, literally: sign]"[69]. Next, the couple is shown in embrace, with Multipos standing outside of the vessel.[70] As a result, a first child appears, now in a "samimas" that has taken on the form of a matrix[71] (Figure 10). The second child, "*secundus puer*", is a dragon, and the author invites the reader – or listener – to have this almost unbelievable sight: "Now look at that child".[72]

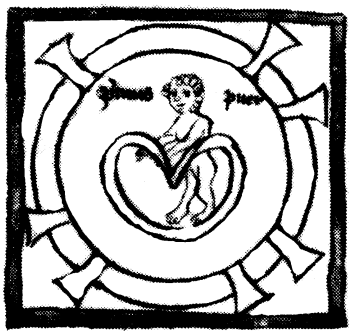


Figure 10: Wien, Österreichische Nationalbibliothek, cod. Vind. 2372, fol. 60 rb (second half of the fourteenth century) (Birkhan ed. 1992, vol. II, p. 78). Gratheus, *Introduction to Alchemy. Primus puer*, the first offspring from Ylarius and Virgo.

Gratheus' text emerged as a major – and possibly first – document testifying to the transformation of analogical relations, particularly between animal generation and the formation of metals, into metaphors. Both linguistic and pictorial metaphors were used for comparison, persuasion, and the conveying of knowledge in the most efficient manner. Analogical relations disappeared together with the corresponding philosophical context and their terms were no longer made explicit. Depicted within glass vessels, the principal metaphorical motif became the union of opposite principles, male and female, in the form of a queen and a king and their subsequent procreation. The purpose of this derivative type of literature was not the elaboration of theories and knowledge, but the transmission of theoretical principles, which were progressively reduced to 'sayings of philosophers', of principles relating to

practica, and of recipes. In order to make sure that these were understood and memorized, authors such as Gratheus condensed them into striking phrases. Rhyme, an artificial and apparently arbitrary nomenclature, and personifications behaving in the most extravagant manner, were employed as mnemonic devices.[73] Corresponding pictures punctuated crucial points and, as if this were not sufficient, Gratheus frequently made verbal statements concerning their presence and invited the reader (or the audience) to look at them.

This type of document does not develop philosophical arguments in order to demonstrate the veracity of alchemy. Instead, striking pictorial forms reinforce the persuasiveness of the written word, itself centerd on rhetorical effectiveness. Moreover, in order to ground pictorial representations in the order of natural (and divine) things and to distinguish them from arbitrary linguistic signs, Gratheus resorted to the fiction of their heavenly appearance. Obvious to everyone, on the firmament there are not only objects to be copied by human art in drawings and fabrication, but also visible forms relating to Christ as both a human and a god, namely the cross, the Holy Sepulcher, and the judge of the Last Day.[74] Of these christological motifs, only that of Christ's haloed head surrounded by glass vessels and that of the holy grave (Figure 14) are pictorially represented.

The early fifteenth-century *Aurora consurgens* marks a further step in the elaboration of pictorial metaphors combined with glass vessels. The oldest and most spectacular copy of this document dates from the 1420s (Zürich, Zentralbibliothek, ms. Rh. 172). On a purely pictorial level, an inventive and high-quality artist developed a core of recurrent alchemical metaphors that relate to human and animal procreation, the dismemberment of bodies (symbolizing calcinations and putrefaction) and motifs such as the eagle and the dragon, which denote mercury as a volatile and as a solidified substance, respectively.[75] In and around glass vessels, the artist metaphorically depicted stages of operation relating to the alchemical art of transformation as well as cosmological and philosophical principles of the art, such as "two are one" and "nature vanquishes nature". Two or more principal metaphors are frequently combined within a single picture, reflecting the increasing use of chains of metaphors. For instance, one of the illustration combines the motifs of Mercury decapitating the sun and the moon with a vase filled with silver and gold flowers (Figure 11).

The thirty-seven illustrations of the *Aurora consurgens* provide a wide range of comparisons taken from nature, whereas practical considerations are pushed into the background. This shift might be explained by the intended readership, since the richly illuminated text was clearly addressed to a milieu of princely patrons.[76] However, these patrons were not merely interested in aesthetic and poetic contemplation but also in personally exercising the art of alchemy, as apparently were the margrave of Brandenburg and Barbara of

Cilli, the wife of the emperor Sigismund to whom the author of the *Book of the Holy Trinity* offered his services during the Council of Constance.[77]

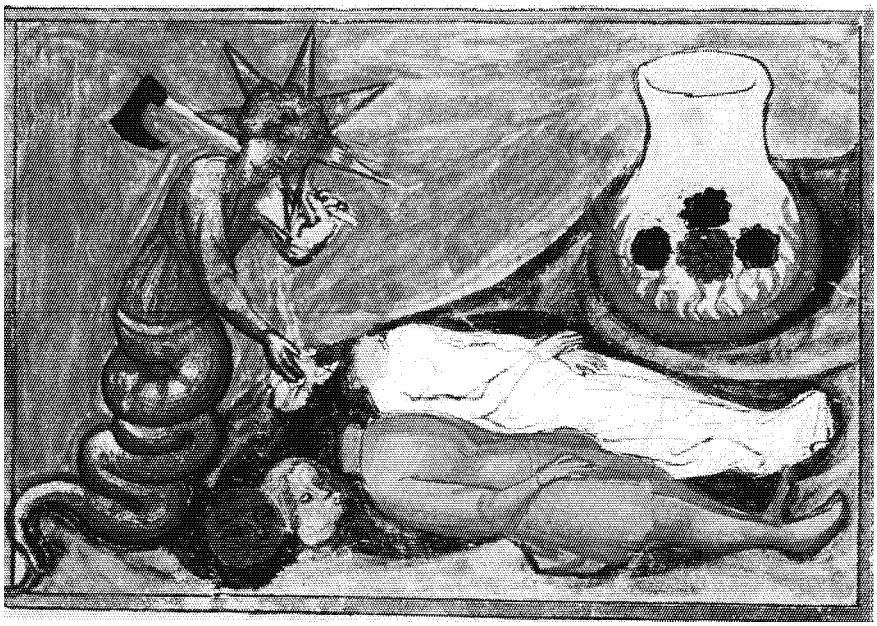


Figure 11: Zürich, Zentralbibliothek, ms. Rh. 172, fol. 27v. *Aurora consurgens* (ca 1420-30). Mercury in the form of a serpent decapitating the Sun and the Moon. Gold and silver flowers in a vessel on the fire.

The *Aurora Consurgens* is also an important testimony to another late medieval pictorial evolution, namely that of synthetic representations of the principles governing alchemy. The document transposes onto the pictorial level an *ekphrasis* in all probability of late antique origin, which has been transmitted to the West by a treatise of Ibn Umail, the *Tabula chemica* (tenth century).[78] This description of wall paintings of a subterranean chamber in a pyramid is combined with that of the purportedly hieroglyphic signs carved into a marble (or emerald) slab resting on the knees of the statue of Hermes, the mythical founder of alchemy.[79] Then follows the interpretation of the pictograms. Two birds holding one another and appearing like a circle symbolize the *topos* of 'two in one'; these birds also take on the form of one of the oldest metaphorical designation for a cosmic principle of unity, namely the dragon biting its tail. Further, the unification of the opposite principles female/male, passive/active, cold/hot, moist/dry finds expression in the cou-

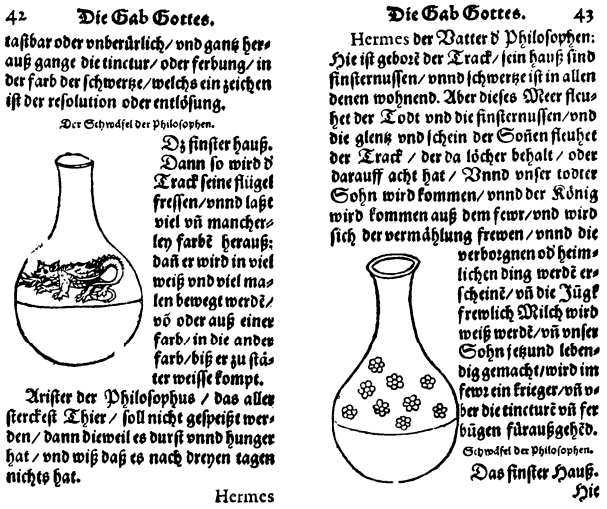
pling of the sun and the moon, a cosmologic motif of central importance since it symbolizes the generation of all things (Figure 12).

Figure 12: *Pandora, das ist die edelste Gab Gottes*, (Anonymous, 1582, p. 241). Hermes with his emerald table, following the description by Ibn Umail (Senior), *Tabula chemica*.

In fact, these pictograms are elaborations of the earliest symbols of Greek alchemy as they appear in Zosimos' of Panopolis *Authentic Memoirs* (Figure 1). In medieval manucripts, the *ouroboros* biting its tail has been stylized into a medallion of three concentric circles with inscriptions referring to the unity of everything and two natures attracting and dominating each other. It is associated with the symbols of the sun, moon, mercury, and sulphur.[80]

According to the narrative of the *Tabula chemica*, the pictures that had been hidden in a pyramid were not only discovered and described but also copied. Thus, the author guaranteed the integrity and truthfulness of the learning deposited by Hermes himself.[81] It may be stated that the *Aurora consurgens* gives a first forceful visual expression of a myth that should be-

come a major theme in the Renaissance period, *i.e.* the myth of the recovery of original knowledge and its methods of deciphering and interpretation. Indeed, the pictorial representation of the discovery of Hermes and his testament dates from the very period of the 1419 recovery of the late antique *Hieroglyphica* by Horapollo. Regarded as the script of divine order, visual hieroglyphic expression became a guarantee for the preservation of original knowledge and of its faultless transmission. Deformation by arbitrary human (verbal) interpretation could not affect the veracity of divinely instituted pictorial signs.


42 Die Gab Gottes.

taſtbar oder vnberürlich/ vnd gantz herauß gange die tinctur/ oder ferbung/ in der farb der ſchwertze/ welchs ein zeichen iſt der reſolution oder entlöſung.

Der Schwäfel der Philoſophen.

Dz finſter hauß.

Dann ſo wird d' Track ſeine flügel freſſen/ vnnd laßt viel vñ mancherley farbē herauß: daß er wird in viel weiß vnd viel malen bewegt werdē/ vō oder auß einer farb/ in die ander farb/ biß er zu ſtäter weiſſe kompt.

Ariſter der Philoſophus / das aller ſterckeſt Thier / ſoll nicht geſpeißt werden/ dann dieweil es durſt vnnd hunger hat/ vnd wiß daß es nach dreyen tagen nichts hat.

Hermes

Die Gab Gottes. 43

Hermes der Vatter d' Philoſophen: Hie iſt geborē der Track/ ſein hauß ſind finſternuſſen/ vnnd ſchwertze iſt in allen denen wohnend. Aber dieſes Meer fleuhet der Todt vnd die finſternuſſen/ vnd die glentz vnd ſchein der Soñen fleuhet der Track / der da löcher behalt / oder darauff acht hat / Vnnd vnſer todter Sohn wird kommen/ vnnd der König wird kommen auß dem fewr/ vnd wird ſich der vermählung frewen/ vnnd die verborgnen od' heimlichen ding werdē erſcheinē/ vñ die Jūgk frewlich Milch wird weiß werdē/ vñ vnſer Sohn ſetzund lebendig gemacht/ wird im fewr ein krieger/ vñ vber die tincturē vñ ferbūgen fürauß gehēd.

Schwäfel der Philoſophen.

Das finſter Hauß.

Hie

Figure 13: *Pandora, das ist die edelste Gab Gottes* (Anonymous, 1582, p. 42-43). The dragon (the philosopher's sulphur) and flowers in glass vessels.

Subsequently, the principal pictorial forms of the *Aurora consurgens* were divided into many branches, but the chronology of this evolution is yet to be established. Major documents of these are a *Rosarius* printed in Francfurt in 1550 and its variants, sometimes bearing the title *Donum dei*.[82] The adaptors maintained that everything depicted has previously been observed, including the appearance of the dragon, thus suggesting a strong relation between observation, truthful imagination, and pictorial representation (Figure 13).[83] On the pictorial as well as on the verbal level, a limited number of *topoi* were subject to continuously varying combinations. Increasingly, alchemical texts and their illustrations became mosaics of already existing documents, which were elaborated in a more or less original manner. They all have in common that the principal operations were codified in a series of stages of transfor-

mation where color and structure change. As long as observable accidental qualities were discussed on a philosophical level, color remained associated with abstract designations for stages of transformation, such as had been codified by the *Summa perfectionis* of pseudo-Gabir. Now, on the metaphorical level, colors were associated with specific shapes of the ingredients, which were described and depicted in the form of allegorised protagonists.

4. Spiritual Fransciscans, alchemy, and visualization

The first part of the early fifteenth-century *Aurora Consurgens* interprets the *Old Testament* in terms of alchemical operation; but, except the figure of Solomon,[84] there are no corresponding pictorial motifs. The aforementioned late fourteenth-century treatise by Gratheus appears to be among the oldest known alchemical documents that include religious pictorial motifs. However, these are exclusively of a christological character: the head of Christ surrounded by a ring of vessels[85] and the resurrection of Christ (Figure 14). Following Gratheus, the tomb of Christ appears on the firmament in the form of a constellation. Here, the cosmic *exemplar* functions not only as a general model for operation, but also as a didactic *exemplum*. The repeated use of the term '*exemplum*' by the author clearly indicates a fusion between these levels[86].

Figure 14: Wien, Österreichische Nationalbibliothek, cod. Vind. 2372, fol. 57va (second half of the fourteenth century) (Birkhan 1992, vol. II, p. 54). Gratheus, *Introduction to Alchemy*. The resurrection of Christ as an example for the process of sublimation.

The origins of textual and subsequent pictorial christological motifs in alchemical texts point back, once again, to the thirteenth and early fourteenth centuries. Here too, in its original doctrinal context, the relation between alchemical theory and operation, on the one hand, and the overall cosmological model, on the other, was one of analogy: the figure of Christ served as a prototype for the relations between the realm of nature and the realm of the supra-natural, the celestial and the earthly, the divine and the human. Afterwards, the earthly life of Christ should become a particularly welcome illustration of diverse operations with the metals. As pointed out by Gratheus, the "*experimenta iudeorum*

are *exempla*" for the treatment of mercury, which has to be "captured, tortured, beaten and deprived of its soul".[87]

In the thirteenth-century doctrinal context, Aristotelian natural philosophy was, as a rule, not supposed to deal with revealed, supra-natural truths, such as Creation, the Trinity, Christology, the sacraments, or the end of the world. Instead, these were the subject matter of theology.[88] With very few exceptions – Constantine's *On the secrets of alchemy* being a point in case – Western alchemical texts written in the thirteenth and early fourteenth centuries conform to that rule.

Differing, anti-scholastic views were put forth in circles of Franciscan spirituals, such as Arnald of Villanova (1240-1311) and John of Rupescissa (d. after 1356). Alchemical documents belonging to this orientation related supra-natural phenomena to the realm of nature and declared artificial transformations achieved by alchemist as being natural to a certain point. Beyond this, namely on the level of substantial transformation, they considered changes miraculous and therefore not apprehensible by rational scientific investigation but only by experiment and illumination.[89] As a consequence, explicit parallels were established between alchemical transmutation and the Eucharistic transformation.

The development of the pharmaceutical branch of alchemy was a major factor for adopting a cosmological model that combined the realms of nature and the supra-natural. This branch specialized in the preservation of the human body and the prolongation of life[90] due to a major innovation, namely the distilling of alcohol.[91] Alcohol (*aqua ardens*, *quinta essentia*, *aqua vita*) was considered incorruptible and rendering the human body unalterable. In his authoritative mid-fourteenth-century treatise on distillation, John of Rupescissa argued that this substance could not be explained in terms of the association and dissociation of elementary qualities (cold/hot, dry/moist). He further promised to demonstrate experimentally (*demonstrabo ex experimenta assumpta*) how a bird, a fish, or a piece of meat once immersed in this liquid is no longer subject to decay.[92] Rupescissa tried to account for the presence of something unalterable within nature by analogy with the Aristotelian first (fifth) essence.[93] However, this theoretical effort proved to be insufficient due to an essential feature of Aristotelian cosmology, namely its strict division between the divine, heavenly and the infra-lunar spheres. As a consequence, the mediator-figure of Christ became the center of a complementary explanatory model.

The distinctive doctrinal features of the corresponding alchemical literature were derived from the theology of the Catalan physician Arnald of Villanova.[94] Briefly outlined, the Arnaldian views, which served as a basis for major developments of late medieval trends in alchemy, are the following. Being the *exemplum* of all things, Christ is the supreme physician (*Summus*

medicus), while the human physician acts as God's instrument[95] (*Ecclesiasticus* 38. 1-11).[96] In turn, in their conforming to Christ's life, the "little ones of Christ" (*parvuli Christi*) become *exempla* of evangelic perfection[97] and, as the last times approach, they help regenerate nature and man both on the corporeal and spiritual level. Their knowledge is acquired by revelation or experiment (*revelatione vel experimento*),[98] by way of signs in nature and in the Holy Scripture.[99] In his *Parabolae medicae*, Arnald made use of the exegetical method of distinguishing between the literal and the spiritual meaning. Parables, similes, and examples of visible things refer to invisible spiritual entities. In this respect, Arnaldus was particularly fond of the Wisdom of Salomon.[100] This hermeneutic principle was adopted in late medieval alchemical textual and pictorial documents, where Biblical texts were systematically interpreted in terms of alchemical work.

The introductory words of the *Tractatus parabolicus* – the main pseudo-Arnaldian text that served as a source for writings and for illustrations referring to the incarnation, the passion, and the resurrection of Christ – quite clearly sets the tone:[101]

> This art [alchemy] may be comprehended through His coming […] for He is the example of all things. And our elixir may be understood according to the conception and generation and nativity and passion of Christ, and be compared to the predictions of the prophets […] And on earth he suffered passion and underwent resurrection, and he visibly ascended from earth to heaven where he rested […]. Do understand how to deal with mercury following the example of Christ.

Christ had suffered four passions, and so does mercury. Among others, mercury had to be put into to a coffin and it had to stay there just as Christ did, and so on.

Regarding the passion of Christ, the *Tractatus parabolicus* is a perfect example of the late medieval tendency to describe Christ's earthly sufferings in the crudest possible way and to exhibit them for viewing in paintings and in sculpture. Moreover, the story of Christ was amalgamated with metaphors taken from human procreation. The operating alchemist had to follow instructions such as:[102]

> Take the pure mother, put it to bed with her son, then subject them to the strictest penitence until they are cleansed from their sins. Then the son will be captured, flagellated, and turned over to the Jews. The son is put back to bed, captured again, and crucified. The sun and the moon will then be darkened. Then the resurrection of the Son will soon take place and you will have to increase the fire.

The Franciscan spiritual movements with their distinctly eschatological outlook conferred a particular social dignity to alchemy: the products of alchemical transformation helped poor and pure Franciscans to fight the impious.[103]

This tradition culminated in *The Book of the Holy Trinity* where means provided by alchemy were offered to help establish the reign of a last emperor. In this document from the period of the Council of Constance, which was dedicated to Frederic, margrave of Brandenburg, in 1419,[104] pictorial motifs relating to political views, theological doctrines, and alchemical transformation of metals were all combined and fused into a single iconographical program.[105] Diverse tortures inflicted on Christ, which had first been described in pseudo-Arnaldian texts and by Gratheus, were now depicted. Christ is shown as a tortured human – mercury – as well as the resurrected god – gold.

5. Geometrical figures as cognitive tools: the Lullian alchemical corpus

The pseudo-Lullian corpus of alchemical writings represent a major late-medieval instance of visualization in so far as figures are no longer *a posteriori* additions, but the very basis of the doctrinal system as well as instruments for organizing its elements, ranging from the most abstract principles to ingredients for recipes. The Catalan philosopher and theologian Ramon Lull (about 1232-1315) made use of figures in the context of neo-Platonic emanantism. Progression from the divine principle down to matter and retrogression from matter up to divinity are graphically represented by way of geometrical figures, above all the circle, together with letters of the alphabet.[106] Lull had intended his *Ars generalis* to be applicable to all sciences; he himself applied it only to astrology and medicine.[107]

In the first half of the fourteenth century, followers of Lull formulated alchemical theory and practice along the lines of his categories. Michela Pereira, to whom we owe the groundbreaking work in the field of pseudo-Lullian alchemy, has identified as a main document the *Testamentum* (ca. 1330-32).[108] She has also reproduced the corresponding figures in drawings, thus laying the ground for further analysis. Since it is impossible to convey an accurate idea of the multiple functions that these figures fulfil within the highly formalized system of pseudo-Lullian alchemy, the following is merely a note intended to draw further attention to this corpus.[109]

Following a by then well-established tradition, (pseudo)-Lullian alchemy combined neo-Platonic theories of knowledge with tenets of Aristotelian natural philosophy and scientific method. For instance, the unknown author of the *Codicillus* pointed out that for apprehending intelligible principles the alchemist must use the eyes of his soul, whereas in relation to signs, *i.e.* the qualities of the means and of the extremes, he has to take his senses for a guide. In this corpus, neo-Platonic emanantism also appears on the cosmological level, divinity being the beginning and the end of all things. Three

principles underlie the physical world: an artificial one, God the creator; an exemplary principle, wisdom; and created matter.[110] Regarding the functioning of the world, the Aristotelian theory of contraries became a central explanatory device and a rule for operating. On the level of general physical principles, hot and cold combined through the medium of dry and moist; on the level of the theory of the formation of metals, the two extremes of quicksilver and sulphur were linked with each other by the chain of intermediate metallic bodies. These means were gradually transformed into extremes either naturally or artificially.

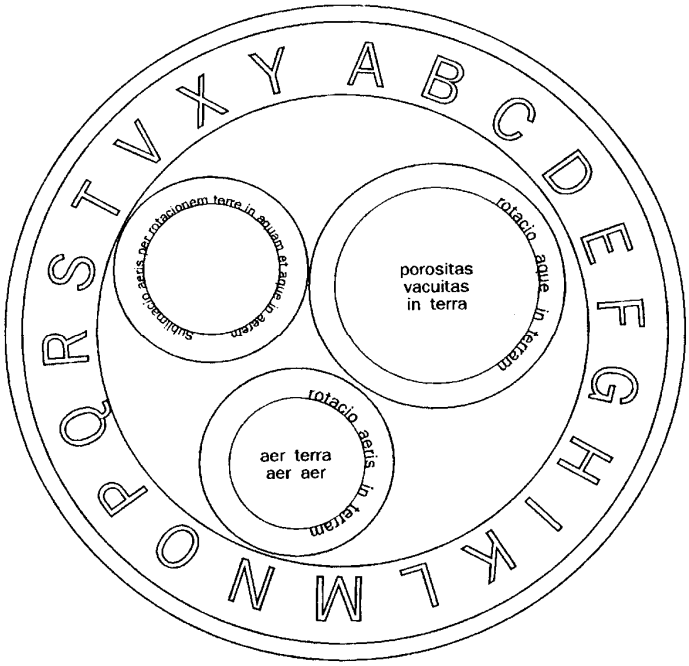


Figure 15: Oxford, Corpus Christi College, ms. 244, fol. 58vb (fifteenth century). Ps. Lull, *Testamentum*. The rotation of elements (Pereira & Spaggiari 1999, fig. 30, drawing F. Di Pietro).

In the corpus of pseudo-Lullian alchemy, the entire body of cosmological, physical, and operational theories were cast into the form of tables, circular diagrams, and geometric figures, such as the square, the triangle, and letter symbolism. Typically, the basic figure of the pseudo-Lullian alchemical *ars*, the circle, symbolized perfection in a neo-Platonic doctrinal context, just as it stood for the Aristotelian concept of the cyclical transformation of the four elements, which in turn determined the natural and artificial transformation

of metals. Combined with geometrical configurations, the letters of the alphabet allowed the alchemist to perceive infra-cosmic relations in an evident way and to know how to perform corresponding operations. Nature rotated the world and its elementary parts,[111] and the alchemist faithfully imitated her:[112] figures both visualized natural mechanisms and indicated how the operator had to proceed (*figura sequens ostendit quomodo*[113]) (Figure 15).

6. Conclusion

The diversity of pictorial forms in major documents of medieval alchemy sheds significant light on the discipline itself. Indeed, alchemy was unique in continually adopting various cosmological models and philosophical theories for justifying artificial transformation of substances and in abandoning them again as quickly. Theory and practice, especially in its innovative aspect, never complemented one another for any length of time.

Only toward the end of the Middle Ages, a somewhat codified pictorial tradition emerged out of very diverse tendencies in visualization. It had an impact that went beyond restricted circles of alchemists, which was in part due to printing, and it consisted of pictorial metaphors associated with glass vessels. These metaphors related to observable accidental qualities of substances, to their effects, to stages of transformation, and also to philosophical principles governing the discipline. The principal theme of these pictorial (and corresponding textual) metaphors was human procreation. Its underlying biological model, which had once been used for analogical inference to mechanisms of the natural and artificial formation of metals and minerals, was no longer made explicit. However, literary documents with this type of visual forms increasingly divorced from practice.

The second major tendency in late medieval alchemical imagery consisted in presenting synthetic tables of the theoretical principles that governed the discipline. Here, pictorial units were combined with corresponding doxographic verbal units. These tables were intended to convey the essence of the art, based on the the idea that, unlike the arbitrariness of linguistic signs, pictorial forms can preserve original knowledge.

The third category of late medieval alchemical documents where pictorial forms played a central role was pseudo-Lullian alchemy. Unlike the didactically oriented documents, they continued to carry the body of scholastic Aristotelian natural philosophy along with tenets of the neo-Platonic philosophical tradition regarding the cognitive function of visual figures.

Ultimately, however, the bulk of practice oriented alchemical writings, which tended to be centred on distillation, was devoid of pictorial forms other than those of apparatus.

Notes

[1] The supposedly first translation of an alchemical work is Morienus 1974. Generally, the work is quoted by a somewhat briefer title, *De compositione alchimie*, or it is simply referred to as 'the Morienus' (see Lemay 1990-91).

[2] Berthelot 1889, pp. 92-126; Berthelot 1887, vol. 1, fig. p. 132; Zosimos of Panopolis 1995, pl. II, p. 241 (the illustrations are taken from Berthelot); Partington 1937.

[3] Vatican City, Biblioteca Apostolica Vaticana, ms. Pal. lat. 978, fol. 33r-41v (additions: fol. 43v-46v): *Dominus Albertus Magnus super alkimiam*; *cf.* ch. 2 (fol. 34r). For instance, the symbol for metals is an *Y* with a transversal stroke on the stem and the symbol for sulphur is *S*. These symbols are used in the text and they are also listed in the lower margin of the folio. For the manuscript, see Thorndike 1936 and Kibre 1959. The *Semita recta* in this manuscript is similar to but not identical with Albertus Magnus 1890 and Heines 1958. For variant texts, see Kibre 1944 and Paneth 1929.

[4] See the signs reproduced in Ganzenmüller 1939, pp. 120-121.

[5] On these issues, see the essays by R. Hooykaas, particularly Hooykaas 1983.

[6] Dominicus Gundissalinus 1903, p. 20.

[7] *Ibidem:* "*Scientia alquimia* […] *est scientia de conversione rerum in alias species*." Vincent of Beauvais, *Speculum naturale*, VII. 6: "*Per artem alchymiae transmutantur corpora mineralia a propriis speciebus ad alias, praecipue metalla*" (Douai, 1624).

[8] Avicenna 1929, English translation in Grant 1974, pp. 572 sq. A partial edition is also included in Newman 1991, appendix I, pp. 49-51.

[9] Sambursky 1956, p. 14. For Aristotle's use of this principle and for a bibliography, see Obrist 1993.

[10] *Ibidem*.

[11] Obrist 1996, pp. 236 sq.

[12] Aristotle 1965, II. 10-11.

[13] Aristotle 1962, IV. 6, 8.

[14] Aristotle 1990, 734b 22 sq.; Obrist 1996, pp. 227-232.

[15] Lloyd 1966, pp. 378 sq.

[16] Aristotle 1990, 743a 29; Vuillemin 1967, pp. 17 sq.

[17] Albertus Magnus 1890, IV. *Tract. unic.* 1; Albertus Magnus 1967. For quotations, see Obrist 1993, pp. 50-51; Obrist 1996, p. 266.

[18] Albertus Magnus 1890, III. 1. 7.

[19] On the history of this idea, see Panofsky 1989, pp. 27 sq.

[20] Lindberg 1982, pp. 14-16.

[21] Riddle & Mulholland 1980, p. 220. The *Commentary* on Aristotles' *Meteorologica* is dated 1250-1254.

[22] "*Horum autem vasorum est figura talis, quod inferius vas sit abcd, superius autem efg, et operculum sit figura h: sic igitur etiam erit in natura*" (Albertus Magnus 1890, III. 1. 10; Albertus Magnus 1967, p. 183-184). Wyckoff reproduces the figures in a manuscript of the Bodleian Library in Oxford, Ashmole 1471, fol. 33v (pl. II).

[23] Aristotle 1971, II. 4, 287b 4-14 (fig. p. 163).

[24] Robert Grosseteste, *De lineis, angulis, et figuris*. For the quotation, see Lindberg 1982, p. 12.

[25] John Scot Eriugena, 1978-1981, III, 625 A-626 A; Jeauneau 1996-2000; Yates 1960, p. 43.

[26] Singer 1946.

[27] The author identifies himself as follows, ch. 7: "I compiled this work; I Constantine of the Pisan nation, not Constantine the African, who wrote a book on medicine which he entitled *Pantegni Constantini* – from *pan* meaning 'all' and *tegni*, meaning 'art', that is 'all the art of medicine'. Similarly, this work is called *Panegni Constantini on the Whole Art of Alchemy*, but it is unknown to most people" (Constantine of Pisa 1990, pp. 83, 247). See also Obrist 1993.

[28] Constantine of Pisa 1990, ch. 15, pp. 91-92/256.

[29] Constantine of Pisa 1990, ch. 15, pp. 93/256.

[30] Constantine of Pisa 1990, Prologue, pp. 70/232. The definition of metals as homeomerous substances is based on Aristotle's *Meteorologica*, IV. 8, 384b 31-35. Constantine explains that they are "*unius generis*" (Prologue, pp. 65/227; comm., p. 162).

[31] Obrist 1982, pp. 67-116; Obrist 1993, pp. 137-144.

[32] Constantine of Pisa 1990, ch. 7, pp. 84/79-80; Obrist 1993, p. 135.

[33] Constantine of Pisa 1990, ch. 2, pp. 73/235-6: "*Sed necesse est scire ordinem planetarum in omiomeris, id est in metallis, ut habetur in hac tabula*."

[34] Constantine of Pisa 1990, ch. 2, pp. 74-75/237: "*Quo idcirco ut sciatur huius scientie plenitudo, debet sciri motus superiorum in omiomeris, et per hanc tabulam que dicitur domus planetarum in signis*." Tables from Glasgow, University Library, ms. Ferg. 104 (fol. 43v, 36v, 44v, 45r, 45v, 46r, 46v, and Vienna (fol. 35 rb, 44rb, 45rb, 46va, 47ra, 47vb, 50r) are reproduced on p. 321-327.

[35] Constantine of Pisa 1990, ch. 2, pp. 75-76/238-9: "[…] *ut habetur in primis in hac tabula*."

[36] Constantine of Pisa 1990, ch. 3, pp. 77-78/240-241: "*De bonis lunationibus, sive malis, aut de operationibus, videndis habetur in hac tabula precedenti et per abundantiam in subsequenti de quadraturis bonis et malis, et de operationibus in eisdem tabula docebit nunc et in presenti*."

[37] For this type of illustration, see Obrist 1993, fig. 1d. For the spheres as a memory system, see Yates 1966, p. 111, fig. 1 and p. 116, fig. 1.

[38] Petrus Bonus 1660, ch. 9, p. 592; Crisciani 1973.

[39] Albertus Magnus 1890 & 1967, III. II. 1 sq. For the color, see III. II. 3.

[40] Albertus Magnus 1890 & 1967, I. I. 1.: "*Cum autem in multis de particularibus fiat tractatus, oportet nos prius ex signis et effectibus cognoscere naturas istorum, et ex illis devenire in causas eorum et compositiones: eo quod ex signa et effectus nobis sunt magis manifesta. In universalium autem natura* […] *erat procedenum e converso, a causa videlicet ad effectus et ad virtutes et signa*." Wyckoff translates 'signa' by 'evidences'.

[41] Albertus Magnus, 1890, III. II. 6 (Albertus Magnus 1967, p. 200).

[42] Albertus Magnus, 1890, III. II. 3 (Albertus Magnus 1967, p. 192). In the sections devoted to Aristotelian physics and method, Constantine even explains the meaning of the letter 'O' as being "so called from seeing (*oculando*) through effects, for

often what the eye sees, the heart believes, especially by experience" ("*Sequitur litera O, ab oculando dicta per operationes, quia sepe quod oculus videt cor credit, maxime per experientiam*" [Constantine of Pisa 1990, pp. 97-98/263]).

[43] Crisciani 1998; for a discussion of various alchemical texts which are not mentioned here, including Petrus Bonus, see pp 88 sq. The notions of 'experience' and 'experiment' conform to an epistemological frame that is shared by alchemy and medicine, see also Agrimi & Crisciani 1990, pp.9-49.

[44] "*Quod scimus loquimur, et quod vidimus testamur: videmus species diversas recipere formas diversas diversis temporibus: sicut patet in arsenico, quod est rubeum, et per decoctionem et assiduitatem erit nigrum, per subimationem erit album, semper tale. Et forte aliquis diceret, quod tales species de facili possunt transmutari de colore in colorem, sed in metallis impossibile. Quibus respondeo ex evidenti causa per diversas probationes et evidentias, eorum errorem penitus destruens: Videmus enim ex argento generari azurum, quod dicitur transmarinum: quod tamen cum natura sit perfectum, carens omni corruptione, facilius videtur, et est destruere accidentale quam essentiale: videmus enim cuprum recipere colorem citrinum ex lapide calaminari* […] *Videmus et ferrum converti in argentum vivum* […]" (Pseudo-Albertus Magnus 1890, pp. 548-549; Heines 1958, pp. 10-11; Halleux 1982, pp. 75-8).

[45] "*Et hoc ideo, quia ars esse non potest nisi a certis et determinatis principiis inchoat artifex; et regulare se debet per signa demonstrativa, quae sunt colores in opere apparentes*" (Anonymous 1702, ch. 53, p. 899). For this and other similar quotations, see Pereira 1992, p. 141, n. 50. For a modern French adaptation of the *Codicillus*, see Anonymous 1953.

[46] *Ibidem*, p. 139.

[47] Roger Bacon 1962, pp. 583-4.

[48] "*Demonstrativa principia generalia, quibus artifex signis praecognitis insignitus, veritatem postulantem artificialiter informat, sunt illa signa quae magis habitu infixa materialibus principiis successive in decoctionibus emittitur, ut sunt 4 principales colores* […] *Per illorum notitiam administrare sciat cautus artista id de quo a natura per signa demonstrativa cognoscet in practica*" (Pereira 1992, p. 142, n. 54).

[49] John Dastin, *Rosarius*: "*Quatuor tamen sunt colores principales: niger, albus, citrinus et rubeus* […] *Colores itaque te docebunt quid facias de igne, ipse namque ostendent quot tempore, et quando ignis primus, secundus et tertius est faciendus; unde si diligens fueris administrator, colores te docebut quid fieri oporteat*." Quoted in Pereira 1992, p. 142, n. 55 (Manget, vol. II, 309-324; cf. p. 320-1). On John Dastin, see Thorndike 1934, vol. 3, pp. 85-102.

[50] Thorndike 1934, vol. 3, pp. 91-92.

[51] Newman 1991.

[52] Berthelot 1893, vol. 1, pp. 68 sq., 149-162.

[53] Paris, Bibliothèque nationale de France, ms. lat. 7156, fol. 138r-142v. Berthelot 1889, vol. 1, pp. 71, 155-166.

[54] Pseudo-Albertus Magnus 1890, p. 551; Heines 1958, p. 16.

[55] "*Furnelli distillatorii sic faciendi sunt: fiant ut supra de argilla* […] *furnus vero sit amplior superius quam subtus id hunc modum, ut eius figura demonstrat*" (Pseudo-Albertus Magnus 1890, p. 551; Heines 1958, pp. 16-17).

[56] Singer 1928-31, vol. 1, n. 177.

[57] Paris, Bibliothèque nationale de France, ms. lat. 7156, fol. 141r (late thirteenth century). Reproduction in Berthelot 1893, vol. 1, p. 161.

[58] Glasgow, University Library, ms. Hunt. 110, fol. 33v: "*Tunc habeas fornellum rotundum* […] *habens foramen ubi vas et ignis imponuntur cuius haec est figura. Istum furnum caleficias donec candescat*."

[59] Birkhan (1992) provides it with the title *Introduction to Alchemy*.

[60] Gratheus 1992, ll. 55-8.

[61] Gratheus 1992, ll. 20-54.

[62] Gratheus 1992, ll. 703 sq., 719-720, 736-739: "*Hets spiegel ende exemplare/ van alkemien openbare; Hier beghint dat men mach scouwen/ an tfirmament in goeder trouwen/ enen spiegel die es scone* […]". See also ll. 1405-15.

[63] Gratheus 1992, ll. 1395-1416: "*Alle dese vate siet men wet/ inden troon met sterren beset* […] *Siet hier na den trone/ ene figure scone/ dar an moghen leren/ vrouwen ende heren/ alkemie kinnen/* […] *siet up desen cyrkel*." For the immediately following illustration of Christ's head and the heavenly round of vessels, see Birkhan 1992, p. 86. Augustine 1956, *Enarrationes in psalmos*, xlx.4

[64] For the latter, see Gratheus 1992, figs. on pp. 32, 36.

[65] Gratheus 1992, ll. 63-5: "*Bi figuren willic v toghen/ die vate die ten werken doghen/ die suldi van glase doen maken*".

[66] Zosimos of Panopolis 1995.

[67] Stapleton 1933.

[68] Gratheus 1992, ll. 400-18, fig. on p. 30.

[69] Gratheus 1992, ll. 1073-4, fig. on p. 66: "*Multipos eist gheheten/ dat es sijn tekin wildijt weten*".

[70] Gratheus 1992, fig. on p. 70.

[71] Gratheus 1992, fig. on p. 78.

[72] Gratheus 1992, l. 1352, fig. on p. 82: "*Nu siet hier tkint ane*".

[73] The classic on these issues remains F. A. Yates, *The Art of Memory*, London, 1966.

[74] For the presence of christological motifs, see *infra*, Notes 85-87.

[75] For the textual sources, see Obrist 1982, pp. 210, 213.

[76] Obrist 1982, pp. 188-9.

[77] Obrist 1982, pp. 119 sq.; Obrist 1986, pp. 50 sq.

[78] Zürich, Zentralbibliothek, ms. Rh. 172, fol. 3v. Obrist 1982, pp. 190-208, plate 49.

[79] Ibn Umail, *Tabula chemica*: "I saw on the roof of the galleries a picture of nine eagles with out-spread wings […] On the left side were pictures of people standing ... having their hands stretched out towards a figure seated inside the Pyramid, near the pillar of the gate of the hall. The image was seated in a chair, like those used by the physicians. In his lab was a stone slab. The fingers behind the slab were bent as if holding it, an open book. On the side viz. in the Hall where the image was situated were different pictures, and inscriptions in hieroglyphic writing [*birbawi*]" (Stapleton 1933). The Latin (very corrupt) text is in *Theatrum chemicum*, Strasbourg, 1660, vol. 5, 192-239: *Senioris antiquissimi philosophi Libellus*; cf. 193-194). It is preceded by the illustrations of the statue with its table in the midst of a crowd of philosophers and the eagles. On the problem of translation, see Ruska 1935-36.

[80] Zosimos of Panopolis 1995, pl. II, p. 241 (for an extensive commentary by M. Mertens, see pp. 180-184); Berthelot 1887, vol. 1, fig. on p. 132.

[81] Senior, *Tabula chemica* (*Theatrum chemicum*, 1660, vol. 5, 193-194).

[82] Telle 1980; Telle 1992; Thorndike 1934, pp. 88 sq. The German translation and adaptation is entitled *Pandora, das ist die edelste Gab Gottes* (Anonymous 1582).

[83] Anonymous 1582, pp. 18-9.

[84] Obrist 1982, p. 240, ill. 43.

[85] Gratheus 1992, ll. 1407-15, fig. on p. 86.

[86] Gratheus 1992, ll. 737-742, 815-847: "*Vanden sterren die hier sijn bleuen/ willic noch exempel geuen/ dat tekin es na thelich graf/ dat ons god te kenne gaf/ oostwaert andt firmament/*[…] *westwaert ant firmament/ heft ment dicken ooch bekent/* […] *Hier willic hu ghewaerlike/ alle die wareit toghen/ dat ghijt siet metten oghen/ als het state ant firmament/ sone suldijs niet wesen blent/ alst regneert suldijt wel/ verstaen an desen cyerkel*." This last passage about truthful visible things on the firmament is concluded by an invitation to look at the image of a circle representing the Resurrection of Christ (Birkhan 1992, p. 54).

[87] Gratheus 1992, ll. 793-802: "*Al seidic hu hiert to uoren/ experimenta iudeorum/ het was exempel al/ als ic noch wel tonen sal/ die joden vinghen onsen here/ dien si pijnden harde zere/ anede tormenten ende Aldus/ so wert geuaen Mercurius/ ende wert gepijint ande geslagen/ ande sine siele vut ghedragen*".

[88] Dales 1984; Bianchi & Rand 1990, pp. 86 sq.

[89] For a detailed discussion of these theories, see Petrus Bonus 1660, pp. 580 sq.

[90] Paravicini Bagliani 1991, Getz 1997, Calvet 1990-1991, Pereira 1993, Pereira 1995.

[91] For one of the crucial medical texts, see Taddeo Alderotti 1913-1914, Forbes 1970. For archaeological evidence, see Moorhouse 1972.

[92] John of Rupescissa, 1572, vol. 2, p. 368.

[93] Obrist 1993, pp. 60-3; Obrist 1996, pp. 274-6.

[94] On the Arnaldian alchemical corpus, see Thorndike 1934, pp. 52-84. In recent times, this subject has been treated, above all, by Calvet 1993, pp. 101-2; Calvet 1991.

[95] This is based on Crisciani 1978, pp. 274, 281.

[96] Crisciani 1978, pp. 270, 281, 284.

[97] Crisciani 1978, p. 251; Calvet 1995.

[98] Crisciani 1978, pp. 272-3.

[99] Crisciani 1978, p. 250.

[100] Arnaldus of Villanova, *Commentum magistri Arnaldi de Villa nova super suis parabolis* (*Arnaldi de Villanova medici acutissimi Opera nuperrime revisa: una cum ipsius vita recenter hic apposita. Additus est etiam Tractatus de philosophorum lapide intitulatus*, Lyon, 1520), fol. 272ra – 272vb. Inc.: "*Omnis medela procedit a summo bono. Medela est beneficium sanationis* […]". Cf. fol. 272 va: "*Nam invisibilia per visibila designantur et ab ista consideratione vocaverunt supra in titulo canones his descriptos parabolas* […] *Parabola enim similitudo interpretatur, et unusquisque istorum canonum medicationis corporalis est similitudo vel exemplar canonis particularis ad medicationem spiritualem quia vivens est commune nomen tam corpori quam spiritui*." Diepgen 1922, pp. 66-7.

[101] (Pseudo-)Arnaldus of Villanova, *Tractatus parabolicus* (Venise, Biblioteca Nazionale S. Marco, cod. lat. VI. 214, fol. 164v-168v, dated 1472); *cf*. fol. 164v. The text has been edited by Calvet (see References) but we have not been able to consult it.

[102] Venise, Biblioteca nazionale Marciana, ms. VI 214, fol. 165v-166r.

[103] John of Rupescissa 1572, vol. 2, ch. 2, p. 368.

[104] Obrist 1982, pp. 117, 266-268, ill. 9-26.

[105] Numerous manuscript copies were made in Germanic lands. For these, see Ganzenmüller 1939, pp. 93 sq.; Obrist 1982, pp. 261 sq.

[106] Yates 1960.

[107] Yates 1954, pp. 118 sq.

[108] Pereira 1989; Pereira & Spaggiari 1999; Pereira 1992, pp. 87 sq.

[109] The diagrams of the Oxford manuscript, Corpus Christi College, ms. 244, have been drawn by F. di Pietro in Pereira & Spaggiari 1999, pp. cxxxix-clxiv. Pereira 1995.

[110] Pseudo Lull 1707, p. 710. For the corresponding figure, a trisected circle enclosed within a triangle, see ch. 5, p. 712.

[111] See Pereira 1992, pp. 180-191. "*Haec est cathena deaurata et rota circularis totius mundi, per quam natura sagax omnia sua regit instrumenta rotanda et circulando, transeundo in circuitu* […]*".* (Pseudo Lull, 1707, ch. 79, p. 755); for an extensive quotation, see Pereira 1992, p. 180.

[112] "[…] *dictus lapis oportet ut creetur ex 4 elementis rotatis in 4 circulis sphericis ligatis cum ligamentis cathenarum deauratarum, sicut sua actio tibi potest manifestare cum clara experientia*" (Pseudo Lull, 1707, ch. 7, p. 809; Pereira 1992, p. 182, n. 60). "*Totum autem secretum et modus operandi in rotatione elementorum consistit, verum nisi circulum naturae propriae prius perfecte cognoveris, illorum circulationis notitiam non poteris* […]" (Anonymous 1702, ch. 71, p. 910; Pereira 1992, p. 182, n. 62).

[113] *Ibidem*: "*Figura sequens ostendit, quomodo elementa per artificium constituunt unum elementum rotundum* […]" (quoted by Pereira 1992, pp. 190-1, n. 83).

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