Technology and Alchemical Debate in the Late Middle Ages

*By William Newman**

THE MEDIEVAL ATTITUDE toward technology is one of the more interesting topics available to historians concerned with the transition from antiquity to modernity. Considerable debate has focused on the sweeping claims made by Lynn White for the social and cultural impact of technological changes wrought in the Middle Ages.[1] Others, such as Guy Beaujouan and James Weisheipl, have looked at Scholastic classifications of the arts and sciences and found a higher appreciation for the role of the artisan in society than earlier sources betray.[2] Despite the growing consensus that the Middle Ages provided a fertile seedbed for technological development, one significant contemporary debate has been largely overlooked, namely, the late medieval dispute over the importance of alchemy—whether it fit into the legitimate fields of knowledge and whether its claims were possible or even legal.[3] Why should we consider this topic within the context of medieval technology? As I shall show in this essay, alchemy provided a natural focus for the issue of man's artisanal power in the natural world.

The medieval world view was marked by a deep division between art and nature. Stemming partly from Aristotle, and partly from other Greek, Latin, and

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[1] Lynn White, jr., *Medieval Technology and Social Change* (Oxford: Oxford Univ. Press, 1962). A generally positive assessment of White's work can be found in Brian Stock, "Science, Technology, and Economic Progress in the Early Middle Ages," in *Science in the Middle Ages,* ed. David C. Lindberg (Chicago: Univ. Chicago Press, 1978), pp. 1–51. For general treatments of medieval technology, see Bertrand Gille, *Histoire générale des techniques,* ed. Maurice Daumas, 5 vols. (Paris: Presses Universitaires de France, 1962–1979), Vol. I, pp. 427–598, and Vol. II, pp. 2–139; and Jean Gimpel, *The Medieval Machine* (New York: Holt, Rinehart & Winston, 1976). For the aura of magic surrounding technology in the Middle Ages see William Eamon, "Technology as Magic in the Late Middle Ages and the Renaissance," *Janus,* 1983, *70*(3–4):171–212. See also Bert Hanson, "Science and Magic," in Lindberg, *Science in the Middle Ages,* pp. 483–506.

[2] Guy Beaujouan, *L'interdépendence entre la science scolastique et les techniques utilitaires (XIIe, XIIIe, et XIVe siècles)* (Conférence faite au Palais de la Découverte, ser. D, 46) (Paris: Université de Paris, 1957); James Weisheipl, "The Nature, Scope, and Classification of the Sciences," in Lindberg, *Science in the Middle Ages,* pp. 473–474, 480; and Weisheipl, "Classification of the Sciences in Medieval Thought," *Mediaeval Studies,* 1965, *27*:54–90. See also Jan Legowizc, "Le problème de la theorie dans les *artes illiberales* et la conception de la science au moyen âge," in *Arts libéraux et philosophie au moyen âge: Actes du quatrième congrès internationale de philosophie médiévale* (Montreal: Institut d'Etudes Médiévales, 1969), pp. 1057–1061.

[3] On the issue of legality in this context see Johannes Chrisippus Fanianus, *De iure artis alchemiae . . .* , in J. J. Manget, *Bibliotheca chemica curiosa,* Vol. I (Geneva, 1702), pp. 210–216.

Arabic sources, this view placed strict boundaries on the conceptual limits of technical innovation. The twelfth-century monastic writer Hugh of Saint Victor, famous for his influential inclusion of technology in the field of the sciences, wrote that "the products of artificers, while not nature, imitate nature, and in the design by which they imitate, they express the form of their exemplar, which is nature." Here Hugh is merely echoing the conviction of ancient Greek philosophy that the various branches of the "mechanical arts," what we would call technology, were originally learned by copying natural processes. As he also writes, "The human work, because it is not nature but only imitative of nature, is fitly called mechanical, that is adulterate."[4] The pejorative view that the mechanical arts derived their name from the Greek word for adultery (*moicheia*), because of their trickery, was of course widespread in the Latin West.[5] Although man could copy nature by means of art, his products—however cunning—could never be identical to their natural models. Hugh of Saint Victor was one of the more appreciative writers to consider the "adulterine arts," among which he grouped "fabric making, armament, commerce, agriculture, hunting, medicine, and theatrics,"[6] but he too considered them to be born of—and limited to—the mimicry of nature.

Latin alchemists did not generally strive to vitiate the principle enunciated by Hugh of Saint Victor; on the contrary, few medieval alchemical works fail to pay homage to the notion that "art imitates nature." But alchemical writers, unlike those in the mainstream of the Scholastic tradition, were willing to argue that human art, even if it learned by imitating natural processes, could successfully reproduce natural products or even surpass them. In so doing the alchemists of the Middle Ages developed a clearly articulated philosophy of technology, in which human art is raised to a level of appreciation difficult to find in other

[4] *The Didascalicon of Hugh of Saint Victor,* ed. and trans. Jerome Taylor (New York: Columbia Univ. Press, 1961), pp. 51, 55–56 (all quotations here from Hugh's *Didascalicon* are from Taylor's English translation). Taylor suggests that Hugh's depiction of the relationship between art and nature is drawn from Chalcidius's early medieval commentary on the *Timaeus*. See also, e.g., Aristotle, *Meteorologica,* 381b6–7; *Physics,* 199a15–17. Further sources are explored in Kurt Flasch, "Ars imitatur naturam," in *Parusia: Studien zur Philosophie Platons und zur Problemgeschichte des Platonismus* (Frankfurt: Minerva, 1965), pp. 265–306. Stock has found Hugh of Saint Victor's inclusion of seven mechanical arts among the traditional liberal ones "in an early *Ysagoge in theologiam,* in an exposition of Martianus of Capella, and in the *Aeneid* commentary attributed to Bernard Silvester": "Science, Technology" (cit. n. 1), pp. 45–48. See also George Ovitt, Jr., "The Status of the Mechanical Arts in Medieval Classifications of Learning," *Viator,* 1983, *14*:89–105, and Lynn White, jr., "Cultural Climates and Technological Advance in the Middle Ages," *Viator,* 1971, 2:171–201, esp. pp. 196–197, where the positive influence of Hugh's *Didascalicon* is discussed.

[5] Lynn White's belief that this spurious etymology "was to have small influence in the West" ("Cultural Climates," cit. n. 4, pp. 192–193) is contradicted by the many examples collected by Peter Sternagel, *Die artes mechanicae im Mittelalter,* Vol. II of *Münchener Historische Studien, Abteilung Mittelalterliche Geschichte* (Kallmünz über Regensburg: Michael Lassleben, 1966). Among these we find the 9th-century monastic writer Martin of Laon, who very possibly originated this derivation of *mechanica,* the 9th–10th-century figure Remigius of Auxerre; the anonymous Bamberger classification of the sciences dating from the early 12th century; the 12th-century writers Richard of Saint Victor, Bernardus Silvestris, and the canonist Hugutio; an anonymous commentary on Aristotle's *Perihermeneias;* and such 13th-century authors as Radolfus de Longo Campo (c. 1216), Vincent of Beauvais, Albertus Magnus, Johannes Balbi (c. 1286), and Engelbert of Admont (fl. 1250–1331); see pp. 45–46, 89–91. Sternagel maintains that learned society gradually devalued the mechanical arts between the beginning of the 12th century and the middle of the 13th; the artisans themselves were of course making real technological progress.

[6] Hugh, *Didascalicon* (cit. n. 4), p. 74.

writings until the Renaissance. The degree to which medieval alchemists and their supporters were forced to develop their positive views about the power of technology in order to salvage their art from the increasingly hostile audience of the late Middle Ages is truly remarkable. This essay will attempt to trace the alchemical debate from its inception in the second half of the twelfth century up to a definite crisis reached in the first quarter of the fourteenth century.[7]

ALCHEMICAL DEBATE IN THE THIRTEENTH CENTURY

Alchemy first made its appearance in the Latin West around the mid twelfth century, when Robert of Ketton translated the *De compositione alchemiae* of Morienus from Arabic into Latin. Between the time of Robert's translation and the end of the fourteenth century, a massive quantity of alchemical literature appeared in Latin, much of it original in character. Yet the university curricula of the Middle Ages did not choose to incorporate alchemy, nor did any institutes of higher learning teach it until the early seventeenth century.[8] Although many medieval alchemical works were apparently written by Scholastic authors, using their characteristically dry, orderly style of exposition, the Scholastics effectually relegated alchemy to the category of marginality by denying it university status.

The reasons for this are complex. It is not enough to say that the medieval universities were bastions of Aristotelianism and that Aristotle had nothing to say about alchemy. Although both halves of this statement are from a modern perspective true, they are misleading. First, some Scholastic writers steeped in Aristotle, such as Albertus Magnus and Roger Bacon, definitely believed in the possibility of alchemical transmutation, as I shall presently elaborate. In fact, the alchemy of the late Middle Ages was a perfectly reasonable and sober offshoot of Aristotle's theory of matter. In this we must carefully distinguish medieval alchemy from the eclectic, Neoplatonic alchemy of the Renaissance, suffused with theosophy and cabalism.

Second, it was commonly believed in the late Middle Ages that Aristotle himself had written about alchemy. At least eighteen different pseudonymous works on alchemy attributed to Aristotle in the late Middle Ages survive in modern libraries. One alchemical work of the late twelfth or early thirteenth century

[7] This topic has been touched on in a brief and rather ahistorical fashion by Reijer Hooykaas, *Religion and the Rise of Modern Science* (Edinburgh: Scottish Academic Press, 1972), pp. 55–58. A more useful synopsis ignores the influence of Avicenna: Chiara Crisciani, "La 'quaestio de alchimia' fra duecento e trecento," *Medioevo: Rivista di Storia della Filosofia Medievale,* 1976, *2*:119–168. Crisciani's useful study of an alchemical systematist of the 1330s falls outside the chronological scope of this essay: "The Conception of Alchemy as Expressed in the *Pretiosa Margarita Novella* of Petrus Bonus of Ferrara," *Ambix,* 1973, *20*:147–162.

[8] For Robert of Ketton see Robert Halleux, *Les textes alchimiques: Typologie des sources du moyen âge occidental* (Turnhout, Belgium: Brepols, 1979), fasc. 39, pp. 49, 70; this work contains by far the best available treatment of the historiography of medieval alchemy as a whole. Some controversy still lingers as to the genuineness of the Morienus text and its ascription to Robert; see Julius Ruska, "Zwei Bücher de compositione alchemiae und ihre Vorreden," *Archiv für die Geschichte der Mathematik, der Naturwissenschaften, und der Technik,* 1928, *11*:28–37; and Lee Stavenhagen, "The Original Text of the Latin *Morienus,*" *Ambix,* 1970, *17*:1–12. On the integration of alchemy into the German universities during the Scientific Revolution see Owen Hannaway, *The Chemists and the Word: The Didactic Origins of Chemistry* (Baltimore, Md.: Johns Hopkins Press, 1975).

attributed to Aristotle exists today in over thirty-five manuscripts, many of them medieval.[9] Similarly, a long section of Avicenna's *Book of the Remedy* that attacked alchemy was habitually attributed to Aristotle by medieval writers. Some, confronted by Aristotle's seeming to support alchemy in one text while attacking it in another, went so far as to devise a developmental hypothesis in which the young Stagyrite was harshly critical but changed his views in the wisdom of old age.[10]

Nor is it sufficient to argue that alchemy was denied university status because of its characterization as a technology (mechanical art). In fact, alchemy occupied a medial position between the arts and the sciences, a position also occupied by medicine. Like medicine, alchemy consisted of a body of theory about certain aspects of the natural world; this theory was then used to support a plethora of manual practices. Thomas Aquinas, to cite one example, variously calls alchemy an "operative science," a "mechanical art," and an "operative art." In the first case, he ranks "medicine, alchemy, and moral [philosophy]" together, since they have a practical use and pertain more to specific subjects than do such fields as metaphysics, physics, and mathematics. In the second and third cases, Thomas groups alchemy with agriculture and medicine as technological pursuits subordinate to physics.[11] But the medieval university curriculum frequently included such subjects as medicine and moral philosophy, despite Thomas's classification of them as, respectively, "mechanical" or "operative." We cannot therefore view the learned disdain for the practical and technological as sufficient cause for alchemy's exclusion from the medieval university, though it may have been a contributing factor.

Far more convincing explanations for alchemy's lack of institutional success than such general ones as the genuine Aristotle's silence or the learned disdain for technology can be found by examining specific medieval documents. It then becomes clear that between the time of alchemy's inception in the mid-twelfth century and the end of the thirteenth century a general backlash against this discipline gradually developed, with mainstream scientific and religious authorities coming to agree in its denunciation. In such an atmosphere it would have been academically unprofitable, to say the least, for a university master to teach alchemy publicly. The result is that alchemical writers went "underground." Anyone who seriously consults the alchemical bibliography of the Latin Middle Ages cannot fail to be impressed by the large number of pseudepigrapha.[12] The

[9] Charles B. Schmitt and Dilwyn Knox, *Pseudo-Aristoteles Latinus: A Guide to Latin Works Falsely Attributed to Aristotle before 1500* (Warburg Institute Surveys and Texts, 12) (London: Warburg Institute, 1985), entry 58; for texts primarily or exclusively of alchemical content, see entries 1–5, 10, 21–22, 25–26, 54–56, 58, 73–74, 85, and 93. Other texts, such as the *Secretum secretorum,* contain substantial sections on alchemy.

[10] Petrus Bonus, *Margarita pretiosa,* in Jean Jacques Manget, *Bibliotheca chemica curiosa,* Vol. II (Geneva, 1702), pp. 76, 80.

[11] See Thomas Aquinas, in his commentary on Boethius's *De trinitate*: "Et ideo etiam quanto alia scientia magis appropinquat ad singularia, sicut scientiae operativae, ut medicina, alchimia, et moralis, minus possunt habere de certitudine." *S. Thomae Aquinatis opera omnia, curante Roberto Busa S.I.* (Stuttgart: Frommann-Holzboog, 1980), Vol. IV, p. 536, col. 3. On p. 532, col. 1, Thomas classes agriculture, alchemy, and "aliae artes quae dicuntur mechanicae" together, again as "operative arts," and at p. 533, col. 1, he explicitly subordinates medicine, alchemy, and agriculture to physics.

[12] Over 30 medieval alchemical works are attributed to Albertus Magnus alone: Pearl Kibre, "Alchemical Writings Ascribed to Albertus Magnus," *Speculum: A Journal of Medieval Studies,* 1942, *17*:499–518. I have recently proved that the *Semita recta,* long considered to have the greatest claim

following discussion will not limit itself to the recapitulation of Scholastic viewpoints concerning alchemy but will also examine some of this pseudonymous literature. We shall find that, in the process of justifying this discipline before its opponents, the alchemists and their supporters gave a conscious and articulate defense of technology, indeed, one of the earliest and most thorough to be found in Latin Christendom. The texts to be discussed make up a disputation literature that may justly be called the "alchemical debate" of the late Middle Ages, although this debate was not really resolved until the university of the Scientific Revolution incorporated chemistry as a part of its curriculum.

THE EARLY THIRTEENTH CENTURY

Our story begins with the English translator Alfred of Sareshel, who around 1200 translated a meteorological section of the Persian philosopher Avicenna's (980–1037) *Kitāb al-Shifāᵓ (The Book of the Remedy)* and inserted it into the fourth book of Aristotle's *Meteorologica,* already translated by Henricus Aristippus.[13] This short text, which came to be known in Latin as *De congelatione et conglutinatione lapidum,* immediately acquired the authority of a genuine Aristotelian production, since it appeared to be the conclusion of the *Meteorologica*'s fourth book.[14] It became thereby the locus classicus for all subsequent attacks on alchemy, and virtually any alchemical writer—whether philosophically sophisticated or not—felt obliged to respond to the arguments of "Aristotle" (i.e., Avicenna). In the process, the *De congelatione* of Avicenna became a focal point for the discussion of human artisanal power in general.

The *De congelatione* contains a description of geological processes, including the formation of the known metals—gold, silver, copper, tin, lead, and iron. Following the doctrines of Arabic alchemy, Avicenna asserts that these six are composed of mercury (mercury is considered not a metal but a component of metals) and sulfur in varying quantities and degrees of purity. It therefore comes as something of a shock when he proceeds to denounce the doctrine of metallic transmutation, upon which alchemical practice is based. Avicenna's main points may be summarized under two heads:

1. Artificial and natural products are intrinsically different, for art is inherently inferior to nature and cannot hope to equal it. Therefore artificers cannot change an inferior metal to a better one, although they can produce passable imitations of the precious metals by inducing superficial characteristics.
2. The true species-determining characteristics of metals cannot be known, since they subsist beneath the level of sense. Since these specific differences are unknown, it will be impossible to bring about the

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to authenticity of any Albertine alchemical work, is a forgery: William Newman, "The Genesis of the *Summa perfectionis,*" *Archives Internationales d'Histoire des Sciences,* 1985, *35*:240–302, esp. pp. 246–260.

[13] James Otte, "The Life and Writings of Alfredus Anglicus," *Viator,* 1972, *3*:275–291.

[14] *Avicennae de congelatione et conglutinatione lapidum,* ed. and trans. E. J. Holmyard and D. C. Mandeville (Paris: Geuthner, 1927), pp. 1–11. Unfortunately, these editors have not supplied a critical Latin text. I have prepared a temporary working edition of the section known as *Sciant artifices* (discussed below) in William Newman, "The *Summa Perfectionis* and Late Medieval Alchemy," 4 vols. (Ph.D. diss., Harvard Univ., 1986), Vol. I, pp. 59–62.

transmutation of one metal into another, for the alchemist cannot manipulate what he does not know.

Avicenna's argument may seem prima facie self-evident to the modern reader, but the terms "species" and "specific difference" are somewhat nuanced. Avicenna's terminology has a logical basis. When he used the term *nauᶜ*, rendered in Latin by Alfred of Sareshel as *species,* he meant above all to refer to the group of characteristics defining a particular kind of thing. To Avicenna there are six such species among metals: gold, silver, copper, iron, tin, and lead. All six belong to the more general *genus* of metals, which he informally defines as "malleable," "fusible," "mineral" (that is to say "mined") bodies.[15] Hence each type of metal shares the set of properties that define the genus: anything that is a malleable, fusible body found in mines will be a metal. But the metals are not all identical: gold, silver, copper, iron, tin, and lead, while metals, also have their own specific differences that make each of them belong to a particular species. The thrust of Avicenna's conclusion is that the specific differences that make metals fall into different species are not such easily perceived properties as melting point, malleability, specific gravity, and color. Instead, the specific differences are really underlying and imperceptible: we cannot know them, and therefore we cannot change them.

It may be tempting for the modern reader to view Avicenna's rejection of alchemy as a forward-looking event that foreshadowed the weaning of chemistry from the "irrational" or "pseudoscientific" doctrines of alchemy. A closer look will reveal, however, that it was Avicenna, and not the alchemists, who held reactionary views. Avicenna begins his attack with the "self-evident" assertion that natural products are intrinsically superior to their artificial counterparts and that the latter cannot possibly match up to the naturally occurring exemplars of which they are copies. As two modern commentators on the *De congelatione* have remarked, Avicenna would have been on the side of "the general public [today], who usually imagine that synthetic indigo, for example, is not veritable indigo, but only a very good imitation."[16]

Avicenna, though basing himself on an ancient prejudice, in fact takes a considerably stronger position about the schism between natural and artificial products than did Aristotle. In the *Physics* (2.8, 199a) the latter allows art either to mimic nature or to carry some of her works to a greater state of perfection than they would otherwise have: "One sort of art perfects that which nature cannot complete, while another sort imitates nature."[17] One almost gets the impression that a personal experience with alchemical counterfeiters led Avicenna to his disdain for human art as expressed in the *De congelatione*. Whatever the sources

[15] Avicenna, *De congelatione,* pp. 32–33. *Nauᶜ* is an Arabic rendering of the Greek *eidos,* used by Aristotle to denote either "species" or "form." In the *De congelatione* Avicenna uses the Latin *species* primarily to distinguish the individual types of metal (such as lead and tin) from the *genus* of metals in general. See Ibrāhīm Madkūr, *L'organon d'Aristote dans le monde Arabe: Ses traducions, ses études, et ses applications* (Etudes Musulmanes, 10) (Paris: Vrin, 1969), pp. 70, 299. For the term itself see Avicenna, *De congelatione,* p. 24. My discussion of this topic owes a debt to conversations with John Murdoch and A. I. Sabra.

[16] Holmyard and Mandeville, in Avicenna, *De congelatione,* p. 41, n. 5.

[17] Aristotle, *De physico auditu,* in *Aristotelis opera cum Averrois commentariis,* Vol. IV (Venice, 1562), fol. 78r, col. 2: "Et omnino ars alia quidem perficit que natura non potest efficere, alia vero imitatur."

for his view, the universal proposition that art is inferior to nature, coupled to the belief that natural species are intransmutable, constituted an attack not on alchemy alone but on the totality of technology and applied science. Avicenna's point was not merely that human technology cannot *outdo* nature but that man cannot even hope to *imitate* nature in a truly successful fashion. Avicenna thus first clothes the ancient philosophical disdain for technology in the form of an "authoritative" enunciation, then spells out the specific reasons for alchemy's failure in terms of Aristotelian natural philosophy. Later we shall find such varied claims as the impotence of demons to work miracles and the inability of horticulturalists to produce new breeds of plants supported by reference to Avicenna's dictum that alchemists cannot transmute species. The effects of the *De congelatione* were by no means restricted to alchemy but served to crystallize an antitechnological bias in many areas.

In response to Avicenna's dictum that species are intransmutable—which came to be referred to in abbreviated form by the incipit *Sciant artifices*—the alchemists developed counterarguments adopting a radical view of technology in which man assumed extraordinary power over nature. Centuries before Francis Bacon's philosophy of nature with its Draconian decree to "put nature to the rack," we find protagonists of alchemy asserting that man's ability to transform the natural world is virtually unbounded. Their justification of human art was not based on vague optimism, however; it was supported by practical observation, analogical reasoning, and a Neoplatonizing Aristotelianism.

One of the earliest sets of counterarguments to the *De congelatione* can be found in a pseudonymous *Book of Hermes* written in the first half of the thirteenth century or before. This work contains a series of elliptical attacks on alchemy, each with its matching rebuttal. The first argument, that metals are natural products and hence may not be replicated by artificial means, implicitly contains Avicenna's axiom that natural products are always better than artificial ones. The author of *Hermes* rebuts this by saying that human technology frequently succeeds better than nature herself, since artificial verdigris, vitriol, zinc oxide, and sal ammoniac are all better than the naturally occurring forms, "which [anyone] who knows about minerals does not contradict."[18] Similarly, the horticulturist improves on nature by making successful graftings. We have here a sort of manifesto proclaiming the power of technology in general and chemical technology in particular. Interestingly, "Hermes" does not deny that art learns by mimicking nature: in order to eviscerate Avicenna's proposition that art is *weaker than* nature, it is sufficient for him to point to the empirical fact that certain products have greater efficacy when prepared artificially.

When the author of *Hermes* comes to Avicenna's assertion that species cannot be transmuted, he adopts the approach of logic: he replies that the metals belong

[18] *Liber Hermetis,* quoting from the partial working edition in Newman, "The *Summa perfectionis*" (cit. n. 14), Vol. I, pp. 63–67, on p. 65, ll. 36–40: "Sal vero viride et dragantum et thutia et sal armoniacus et naturalia et artificialia sunt. Immo et artificialia naturalibus potiora sunt, quod qui de mineriis sciunt non contradicunt." The *Liber Hermetis* has never been printed, or for that matter analyzed. I have found it in the following 13th–14th-century MSS: Cambridge, Trinity College 1400, fols. 131r–133r; Oxford, Bodleian Library (BL), Bodley 679, fols. 20r–21r; London, British Museum (BM), Add. 41486, fols. 218r–222r; Paris, Bibliothèque Nationale (BN), Latin (Lat.) 6514, fols. 135r–v; and in the following 14th-century MSS: London, BM, Sloane 1754, fols. 60r–62r; Palermo, Biblioteca Communale, 4QqA10, fol. 37v (incomplete).

to a single definition, any metal being "a composite, fusible, incombustible, malleable body."[19] Logically, there is no compelling reason why this should be called a genus rather than a species, since such differentiation is merely a matter of degree (a genus is merely comprehended by a more general definition than a species). In providing a single definition for all the metals, the author of *Hermes* can therefore argue that they all belong to a single "species," and that the "species" of which Avicenna speaks are by implication only "more specific species" (*species specialiores*). Thus *The Book of Hermes* does not need the transmutation of species. This purely logical approach to undermining the *Sciant artifices* soon gave way in the West to a more hylomorphic tendency. As we shall see, Albertus Magnus—among others—took Avicenna's *species* to mean a form that "inheres" physically in the substance of a metal in order to determine its particular set of characteristics. Although permissible within the framework of Aristotelian philosophy (where *eidos* means either "species" or "form"), Albert's interpretation would have the effect of turning Avicenna's discussion of *genera* and *species* into an argument about matter and form.

THE MID-THIRTEENTH CENTURY: VINCENT OF BEAUVAIS, ALBERTUS MAGNUS, AND ROGER BACON

The *Book of Hermes,* although it offered a succinct and early defense of alchemy, does not seem to have been known to the three Scholastic authors of the mid thirteenth century most concerned with alchemy, Vincent of Beauvais, Albertus Magnus, and Roger Bacon. The works of these three authorities provide a gauge of the degree of controversy alchemy aroused at that time.

I will dispense with Vincent briefly, since he gives a rambling account of alchemy, devoid of originality. Vincent wrote his *Speculum doctrinale* and *Speculum naturale* between 1244 and 1250.[20] Since these two works contain much the same material on alchemy and on mineralogy in general, I shall focus on the somewhat more orderly *Speculum doctrinale*. The *Speculum doctrinale* places alchemy among the mechanical arts. Alchemy, unlike the sciences per se, is merely useful from a practical point of view—to the metalworker, since it teaches "the examination, intermixture, separation, and transmutation" of the metals, and to the physician, because it aids in the isolation of healthy from harmful components, which "are often found mixed together in simple medicines." Vincent adds that alchemy is descended from the "science of minerals" (*ab illa parte naturalis philosophie que est de mineris*) in the same way that agriculture is derived from the "science of plants." To Vincent, therefore, alchemy "is properly the art of transmuting mineral bodies, such as metals and the like, from their own species to others."[21]

[19] *Ibid.,* p. 66, ll. 57–61: "De speciali vero differentia cui dubium est metalla specialiter non differe, cum in una diffinitione conveniant. Verbi gratia, corpus compositum, in igne fusibile, non combustibile, sub malleo extendibile."

[20] William A. Wallace, "Vincent of Beauvais," *Dictionary of Scientific Biography,* ed. Charles C. Gillispie, 16 vols. (New York: Scribners, 1970–1980) (hereafter ***DSB***), Vol. XIV, p. 35.

[21] Vincent of Beauvais, *Speculum doctrinale* (Venice, 1494), Book 11, Ch. 105: "Ad fabrilem quidem propter metallorum examinationem, commixtionem, disgregationem, transmutationem. Ad medicinam itidem propter substantiarum vel qualitatum salubrium a noxiis que frequenter etiam in medicinis simplicibus permixte sunt separationem. . . . Alkimia proprie est ars transmutandi corpora mineralia a propriis speciebus ad alias, ut sunt metalla et huiusmodi."

So far, Vincent is reasonably consistent: he considers alchemy to be a simple practical art, entirely devoid of theoretical content. But the *Speculum doctrinale* here begins to contradict itself, for the introductory passage is directly followed by passages from alchemical writers giving long theoretical descriptions of the generation of minerals from sulfur and mercury within the earth. Clearly this is a speculative sort of alchemy, not just a mechanical art. A parallel confusion reigns in Vincent's description of Avicenna's attack on alchemy. He quotes Avicenna's broadside without giving his own point of view, then replies with an extract from pseudo-Avicenna containing a number of garbled arguments *in favor* of alchemy.[22]

Vincent's rather complacent and confused account of alchemy is followed chronologically by the *De mineralibus* of Albertus Magnus. Here we find a considerably more coherent assessment. Between 1250 and 1254 Albert took on the task of writing a comprehensive study of mineralogy as part of his endeavor to explain the totality of natural science.[23] Since Albert could find no Aristotelian book on minerals to comment on, he had to turn to the texts of the alchemists.

In the course of his investigation, Albert therefore felt the need to respond to the arguments of the *De congelatione,* which he knew to be a work of Avicenna's. Albert begins his analysis of transmutation with an attack on previous authors who have proposed that all metals share one form, that of gold, in varying states of completion. Arguing from sense, he says that the metals appear to be "stable" (*permanens*); under normal circumstances they do not become other metals. Therefore they must each have their own substantial form by which they are "perfected." Similarly, each metal has its own peculiar set of properties, so their accidents are not common. As a result, "the substances and specific form [*species*] [of different metals] must be different."[24]

Given that Albert believes the metals to differ in their species, we might expect him to uphold the viewpoint of the *De congelatione*. This is not the case, however. In a special chapter he directly attacks the pronouncement *Sciant artifices,* where Avicenna had argued that alchemists could not transmute species. In this chapter it becomes clear that Albert has understood the Latin *species* to mean "specific form."[25] This substitution of "specific form" for "species" allows Albert to circumvent the *Sciant artifices,* since he can now draw on a well-defined Scholastic theory concerning the physical corruption of a preexistent form followed by the induction of a subsequent form. Thus Albert believes that *species*

[22] *Ibid.,* Book 8, Chs. 42, 84.

[23] Robert Halleux, "Albert le grand et l'alchimie," *Revue des Sciences Philosophiques et Théologiques,* 1982, *66*(1):58.

[24] *Albertus Magnus: Book of Minerals,* trans. Dorothy Wyckoff (Oxford: Clarendon Press, 1967), pp. 172–173. Here as elsewhere Wyckoff uses the expression "specific form" for the Latin *species*. Wyckoff's translation, however, obscures the fact that Albert's argument is motivated by the *Sciant artifices* of Avicenna. Like Avicenna, Albert uses the Latin term *species* rather than *forma specifica,* though what he means is closer to the latter.

[25] *Ibid.,* pp. 177–179. For the original Latin see Albertus Magnus, *Mineralium libri quinque,* in *B. Alberti Magni . . . opera omnia,* ed. Auguste Borgnet, Vol. V (Paris, 1890), pp. 70–71. For further evidence that Albert conflates *species* and *forma specifica* see the following passages: "Experimenta autem alchimicorum graves duas nobis hic ingerunt dubitationes. Videntur enim illi dicere quod sola auri species est forma metallorum" (68a); and "Quod si forte concederetur quod substantiam auri inducat, adhuc non est sufficiens probatio ad hoc quod non sit nisi una species metallorum: quoniam calcinando et sublimando et distillando et caeteris operationibus quibus elixir per materiam metallorum faciunt penetrare, corrumpere potest species metallorum quae primitus infuerunt materiae metallorum" (69a).

can indeed be transmuted, inasmuch as one specific form can be destroyed and replaced by another.

Albert's interpretation, however, slightly distorts Avicenna's use of the Arabic term *nauᶜ*, or *species,* in the *De congelatione*. By *species* Avicenna meant primarily a logical entity, in the same way that the term is contrasted to *genus* by logicians. In the *De congelatione* Avicenna does not speak of species as "inhering" in matter, or as being corrupted and induced. Instead, his species are above all abstract categories that existed in the Creator's mind when he fashioned the natural world. To say that such logical species are transmutable would be fatuous indeed, since they represent the distinct underlying concepts by which God created separate metals.[26]

At any rate, armed with his hylomorphic interpretation of "species," Albert says that honest alchemists act toward metals just as physicians do toward their patients.[27] The alchemist first cleans and purifies the old metal, just as a doctor employs emetics and diaphoretics to purge his patient. Then he strengthens the "elemental and celestial powers" in the metal's substance, apparently by adding druglike components and observing astrological "judgments." As a result, the purged metal receives a new and better specific form from the celestial virtues of the stars. Hence the alchemist has not *transmuted* any species: he has only removed one specific form and prepared the way for another to be received.

Albert's benign view of alchemy does not bear witness to a heated debate on this subject. He is not responding to any *moderni* but only to Avicenna and other Arabic authors. The equanimity of his tone, furthermore, seems to reflect a period in which alchemical transmutation was not yet a general subject of irascible dispute. When we turn to Roger Bacon, the atmosphere changes radically.

Roger wrote his *Opus tertium* around the year 1266, as a part of the trilogy also comprising his *Opus maius* and *Opus minus*. The three books were intended as an advertisement for reform, and as such they were sent by special courier to Roger's friend Clement IV.[28] In the *Opus tertium* Roger proposes that alchemy should form the primary means of reforming Scholastic science. He asserts that alchemy teaches things of which Aristotle was completely ignorant, such as the precise generation of minerals, pigments, precious stones, and humors from the elements. Furthermore, since alchemy is the science of the elements per se, while natural philosophy and medicine concern things made out of the four elements, such as the four humors, alchemy is the most basic of the sciences. Hence Roger's approbation of alchemy far exceeds that of Vincent or Albert: whereas they see alchemy as primarily a practical art whose masters have provided empirical examples for real philosophers to explain, he wants to make it the wellspring of all medical and natural knowledge. Although modern historians have stressed Roger's mathematics (to the ultimate misfortune of the poor friar),

[26] Avicenna attacked specific transmutation in at least one other text: the *R. fi ibtāl aḥkām al-nujūm* or *R. al-Ishāra ilā ᶜilm fasād aḥkām al-nujūm*. Georges C. Anawati paraphrases it as follows: "Ce sont des absurdités [specific transmutation]; car pour tout ce que Dieu a créé moyennant la force de la nature, l'imitation artificielle est impossible; comme au contraire les productions artificielles et scientifiques n'appartiennent d'aucune manière à la nature." Anawati, "Avicenne et l'alchimie," in *Oriente e Occidente nel Medioevo: Filosofia e scienze* (Rome: Academia Nazionale di Lincei, 1971), pp. 285–341, on pp. 300–301.

[27] Albertus Magnus, *Book of Minerals* (cit. n. 23), pp. 178–179.

[28] A. C. Crombie and J. D. North, "Roger Bacon," in *DSB,* Vol. I, p. 378.

we must note that in the passage above he explicitly lauds alchemy as "greater than all the foregoing [sciences]," of which the science of mathematics was one.[29]

It is equally significant that Roger nowhere mentions the attack of the *De congelatione* in the three *Opera* addressed to Clement IV. Why, after all, should he have interjected the views of a doubting Thomas into his promotional broadsides? But Roger clearly knew the *Sciant artifices* from an early date, since he supported its point of view in his commentary of about 1245 on the pseudo-Aristotelian *De plantis*.[30] There he universalizes the proposition that "species cannot be transmuted," taking this supposedly Aristotelian view to apply to plants as well as metals. Clearly Roger underwent a serious change of mind between 1245 and the 1260s. If we examine his *Communium naturalium* of 1266, the reason for his new disregard of the *Sciant artifices* appears. Here he attacks its attribution to Aristotle.[31] Despite the view of "fools," he says, the *Sciant artifices* is only a second-rate commentary by Alfred of Sareshel. By replacing the authority of Aristotle with that of Alfred, Roger makes it an easy matter to dismiss the proposition that species may not be transmuted. In the *Communium naturalium* Roger goes far beyond his predecessors in rejecting the theoretical validity of the *Sciant artifices*. Whereas Vincent chose to take no position, and Albert circumvented the issue by interpreting species to mean specific form, Roger simply says that the proposition "species cannot be transmuted" is not true.

Furthermore, he adds that "fools" abuse the authority of Aristotle by attributing this position to him, apparently in attacking alchemy. Since Islamic authors did not attribute the *De congelatione* to Aristotle, it follows that the fools to whom Bacon refers must have been Latin fools. Albert's dispute was limited to Arabs, and Vincent found no need to take sides at all. It is therefore evident that the alchemical debate had grown in magnitude since the 1240s and 1250s, when Vincent and Albert were concerned with mineralogy. Further evidence is the great space given to disputation in alchemical works written after 1250. One such work was written by a practicing alchemist, probably in the last third of the thirteenth century.

ALCHEMICAL DEBATE IN THE LATE THIRTEENTH CENTURY: PAUL OF TARANTO

I have recently shown that Paul of Taranto, a thirteenth-century Franciscan, was the probable author of a famous alchemical text, the *Summa perfectionis,* spuriously attributed to the Arab Jābir ibn Ḥayyān.[32] More pertinent to our present argument, however, is the defense of alchemy that Paul presents in another text, the *Theorica et practica*.

[29] Roger Bacon, *Opus tertium,* in *Opera quaedam hactenus inedita,* ed. J. S. Brewer, Vol. I (London, 1859), pp. 39–40.

[30] "Item, quarto *Metheororum,* 'sciant artifices alkimie species metallorum transmutari non posse,' quare similiter nec species plantarum": Roger Bacon, *Questiones supra de plantis,* in *Opera hactenus inedita Rogeri Baconi,* ed. Robert Steele et al. (Oxford: Clarendon Press, 1911–1940), Vol. XI (1932), ed. Steele and F. M. Delorme, p. 251; see also p. 241.

[31] Roger Bacon, *Communium naturalium,* in *Opera hactenus inedita,* Vol. II (1911), ed. Steele, p. 7.

[32] See William Newman, "New Light on the Identity of 'Geber,' " *Sudhoffs Archiv,* 1985, *69*:76–90; and Newman, "Genesis of the *Summa perfectionis*" (cit. n. 12).

The *Theorica et practica,* as its title implies, is a didactic work comprehending both the theoretical and the practical bases of alchemy. It contains a long defense of this discipline, in which Paul attempts to defuse the *Sciant artifices* of pseudo-Aristotle. Paul prefaces his specifically alchemical comments, however, with a general defense of human art. He begins with a proem, heavily dependent on the pseudo-Aristotelian *Liber de causis,* in which he tries to justify the power of man over nature. He does this by identifying the Plotinian hypostasis *intellectus* with the human intellect, a not-uncommon conflation among thirteenth-century thinkers. Because nature is inferior and subject to intellect, man must therefore be in a position to manipulate and rule nature. Paul then proceeds to a special chapter on the relation of art to nature (see Appendix). Since human intellect rules over nature, he says, artisans such as "sculptors, painters, horticulturists and physicians" have nature subjected to themselves "as matter and instrument." Drawing on Aristotle's *Physics,* Book 2, Paul divides human art into two categories—that which generates an "extrinsic" form, as in the case of painting and sculpting, and that which terminates in an "intrinsic form," such as medicine or agriculture.[33] Those arts that produce an intrinsic form use the Aristotelian primary qualities—hot, cold, wet, and dry—as instruments. Arts inducing an extrinsic form rely on secondary qualities, such as colors and tastes.

Arts such as agriculture and medicine that act on the primary qualities can actually transmute substance, whereas sculpture, painting, carpentry, and other arts that work only on secondary qualities can only induce accidents into their subject. The genuine physician, horticulturist, or alchemist, therefore, produces real changes in essence and substance, because he manipulates the first qualities of matter. False artisans, on the other hand, produce only the appearance of change; they attack the symptom rather than the cause. When Paul comes to the *Sciant artifices,* he uses this bifurcation of the arts to remove its force, saying, "We do not consider the opinion of Aristotle which he writes at the end of the *Meteorologica*—'The alchemists should know that species cannot be transmuted'—to be true unless it be understood in the foresaid way, [that is, as occurring] through purely artificial agents."[34] In other words, the *Sciant artifices* holds only if the artisan employs secondary, "artificial" qualities, since these do not affect the substance of a given subject. Otherwise, if he uses primary qualities, it is indeed possible to induce substantial change and thus to alter species.

Paul of Taranto's argument, although directed mainly toward alchemy, is undeniably a justification of technology in general, since it upholds the power of those arts capable of manipulating primary qualities to induce real change in natural products. In other words, Paul consistently affirms the power of man really to alter and improve natural products. At the same time, his reasoning implicitly contains more than an apology for technical skill per se. By dividing the "arts" into two categories he implicitly distinguishes between pure technol-

[33] Paul of Taranto, *Theorica et practica,* Paris, BN, Lat. 7159, fols. 1r–55r, on fols. 1r–v, 2v, ll. 17–18. Since the *Theorica et practica* has never been printed, quotations are from an edition I have prepared, available in Newman, "The *Summa perfectionis*" (cit. n. 14), Vol. III, pp. 1–237. (See also the Appendix, for a partial edition and translation and the other manuscripts.)

[34] Paul of Taranto, *Theorica et practica,* fol. 4r, ll. 12–15: "Non putamus igitur esse verum verbum Aristotelis quod in fine sui libri scribit in methauris—'*Sciant artifices* species se transmutare non posse'—nisi hoc predicto modo per pura artificialia intelligatur."

ogy (e.g., sculpting, painting, and carpentry) and applied science (e.g., medicine, agriculture, and alchemy).

The difference between these two categories hinges on the second argument of the *Sciant artifices,* where Avicenna, remarking that the differences between metals are not known, asks: "When the [specific] difference is not known, how will it be possible to know whether it is taken away or not or even how it could be taken away? Removal of the accidents within, however, such as taste, color, and weight, or at least their lessening, is not impossible, for reason is not opposed to this."[35] Avicenna's argument relies on the impossibility of the artificer's manipulating that which he cannot recognize, namely, the hidden essential differences that make one metal different from another. The theoretical part of Paul of Taranto's *Theorica et practica,* therefore, is precisely an attempt to become acquainted with these essential principles of the different metals. These are perceived by means of tests performed in the laboratory or foundry. We know, for example, that metals contain sulfur for the following reason: when metallic ores are "calcined"—oxidized by intense heating—they give off a sulfurous, stinking smoke.[36] Some metals, however, contain more sulfur than others. Lead, for example, contains more sulfur than tin and of a more entrenched sort. Paul determines this from the fact that two calcinations of lead leave a yellow, sulfurous calx, while two such firings of tin leave a white calx, although the metal's smoke is still yellow.[37]

The presence of mercury in the metals is proved by similar means. Mercury readily forms an amalgam with gold, silver, copper, tin, or lead, simply by remaining in intimate contact with any of the said metals. The medieval writers even claimed to be able to amalgamate mercury with iron, though this claim was probably the result of observational error on their part. As Paul says, this striking affinity between quicksilver and the then-known metals "is due to a similarity of substance."[38] But he later describes a procedure by which mercury subjected to

[35] Avicenna, *De congelatione,* ed. Newman (cit. n. 14), pp. 61–62: "Differentie metallorum enim non sunt cognite et cum differencia non sit cognita, quomodo poterit sciri utrum tollatur nec ne, vel quomodo tolli possit? Sed expoliacio intus accidentium ut saporis, coloris, ponderis, vel saltem diminucio non impossibilis, quia contra hoc ratio non est."

[36] Paul of Taranto, *Theorica et practica* (cit. n. 33), fol. 8r, ll. 20–24: "Demonstrat etiam sulphuris cum mercurio secundum naturam esse admixtionem pro substantia et tinctura cum ad calcinationem metalla funduntur, maxime si fuerint imperfecta, mollia vel dura, fumus eorum et fetor sulphureus et etiam color in calcibus eorum."

[37] *Ibid.,* of lead, fol. 25r, 11. 24–30: "Probatur [autem] in eo sulphureitas esse duplex, quarum una est adustiva et fixa parum[que], altera⟨que⟩ magis fixa ex eo—quod una eius sulphureitas cito in fumum resolvitur, cuius probatio est sulphureus eius fetor et color; et facit deperditionem corporis in se ipso. Alia vero sulphureitas eius non nisi per difficilem maximum magisterium transit, que quidem remanet etiam in calce eius, cuius etiam probatio est sulphureus fetor et color citrinus." Of tin, fol. 26v, ll. 20–22: "Nam licet post primam calcinationem iovis et reductionem ad ignem magne sue ignitionis, apparet adhuc fumus eius citrinus, quod etiam sicut in saturno est necesse contingere ex resolutione in evolatione partis sulphuree in eo non fixe, tamen quoniam remanet eius calx alba, scilicet in saturno citrina, manifestum est ex hoc sulphureitatem in iove non ita profundatam esse in intimo suo substantie, nec tantam esse, nec taliter fixam sicut est in saturno." In quotations from the original language (notes and Appendix), editorial deletions are in square brackets and editorial interpola sections in angle brackets. (In the translations interpolations are in square brackets.)

[38] *Ibid.,* fol. 7v, l. 32–fol. 8r, l. 8: "Sed et sensus probat in plumbo, et stagno, et luna, et mercurio subtilitatem esse per similitudinem rei, magis autem fit hoc evidens cum ipse mercurius congelatur in massam, licet frangibilem, ad odorem ipsius saturnus vel iovis, cum scilicet liquatis ad ignem his, iam cum incipiunt frigefieri extra ignem, et facta in eis foveola cum forma ligni alicuius, proiicitur intus

the vapor of molten silver or lead is congealed per se "without the admixture of any other."[39] From the modern point of view, the product of this experiment would again be an amalgam. To the alchemist, however, it appeared that the hot, arid vapor of lead served to "dry out" the excess humidity of the mercury, thus allowing it to become a full-blown metal. Hence Paul says that this procedure, by which mercury is "independently" converted from a "spirit" to a metal, shows better than any other demonstration that the "subtlety [of the substance] of the metals" comes from mercury.

Paul supports these experimental demonstrations of the metals' components by an attempt to explain the nature of the metallic principles, sulfur and mercury, in terms of the four primary qualities, hot, cold, wet, and dry. Without going into details, I will point out the thrust of his argument. By arriving at the composition of the two metallic principles in terms of the four qualities, then showing how the two principles can be manipulated to form the six known metals, Paul manages to satisfy Avicenna's objection that the alchemist cannot manipulate that which he does not recognize. Using experimental demonstrations such as those described above and the philosophical framework provided by Aristotle's *De generatione et corruptione* and *Meteorologica,* Paul responds that properly educated alchemists really can recognize and manipulate the primary qualities directly. This ability to recognize qualities is precisely what distinguishes alchemists and physicians on the one hand from carpenters and painters on the other. The latter do not attempt to understand the nature of their material at its most fundamental level. They are technically skilled, but their work operates only on the level of appearance, not fundamental change. In other words they are scientifically uninformed artisans—pure technicians—whom Paul is careful to distinguish from those who derive their skill from a direct knowledge of the four Aristotelian qualities. I can think of no better term for the latter than *applied scientist,* a category already employed in this sense by Lynn Thorndike.[40]

In effect, therefore, Paul has made a distinction between the applied scientist, who understands and employs the true causes of things, and the simple artisan, who works to produce an effect without true knowledge of its causes. As Avicenna said in the *De congelatione,* such an artisan cannot change species, for if the specific difference—the cause of the species—is not known, "how will it be possible to know whether it is taken away or not, or how it could be taken away?"[41] The applied scientist, according to Paul, does understand the causes of species and can therefore change them.

Of the three Scholastics examined earlier, only Roger Bacon matches the pre-

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mercurius. Tunc enim frigefacto tali plumbo vel stagno plene, mercurius invenitur densatus in massam argenteam plumbo vel stagno consimilem."

[39] *Ibid.,* fol. 20v, ll. 12–17: ". . . subtilitas scilicet metallorum ex mercurio fiat potissime sicut probatur ad sensum, quod maxime patet cum per artificium mercurius figitur et fit per se solum verum argentum, aut etiam aurum per tincturam sulphuream, sine alterius alicuius admixtione."

[40] See the term *applied science* in Lynn Thorndike, *History of Magic and Experimental Science,* 8 vols. (New York: Columbia Univ. Press, 1923–1958), *passim;* e.g., in Vol. I, Ch. 5, of the ancient mechanical engineering of Vitruvius and Hero of Alexandria; in Vol. II, p. 81, of pseudo-Farābī's *scientia de naturis*; and in Vol. II, p. 663, of Roger Bacon's *Epistola de secretis operibus*. Attempts like those made in these works to apply philosophical or scientific principles for technological ends must be distinguished from nonscientifically oriented craft traditions in which no attempt to utilize scientific first principles is made.

[41] Avicenna, *De congelatione,* ed. Newman (cit. n. 14), p. 61: ". . . cum differencia non sit cognita, quomodo poterit sciri utrum tollatur nec ne, vel quomodo tolli possit?"

mium put on technology, or rather applied science, by Paul of Taranto. It is possible, however, that the very success of such arguments as Paul's and Roger's led to the condemnation of their views. In the *Theorica et practica* Paul goes to the limit by insisting that "anything short of the animated and the soul itself can be made naturally from anything else with regard to elementary form . . . such as bodies composed of the four elements, as for example stones and metals."[42] In other words, the powers of art are limited only by the human inability to make and infuse another soul. Roger Bacon, in a similar fit of hubris, goes so far as to say that alchemical gold, because it contains the four elements in an even better proportion than natural gold, can restore the human body to a condition of elemental equality like that of Adam and Eve and the resurrected at the end of time. Roger's enthusiastic views may have contributed to his apparent imprisonment during the last fifteen years of his life.[43]

ANTI-ALCHEMICAL SENTIMENT IN THE LATE THIRTEENTH CENTURY AND THE RESULT OF THE DEBATE

What then was the opposite camp doing, while Paul and Roger were concocting their alchemical manifestos? The first direct counterattack by a Latin author that I have been able to locate is contained in a work by the Thomist Giles of Rome (Aegidius Romanus), written between 1286 and 1291.[44] Before turning to Giles, however, it will be useful to summarize briefly the views of his teacher, Thomas Aquinas.

Determining Thomas's opinions on alchemy is not as straightforward a task as one might hope, since his genuine works were sometimes completed posthumously by others. This appears to have been the case with his commentary on the *Meteorologica* of Aristotle: the portions of the text that give a positive portrayal of alchemical transmutation were actually written by another author. The *Summa theologiae,* finished or broken off in 1272, refers several times to alchemy, but only in passing.[45] Fortunately, Thomas's commentary on the *Sentences* of Peter Lombard, probably written between 1252 and 1256, contains a revealing treatment of demonology in which alchemy—though not the main topic—is discussed.[46]

When commenting on Book 2 of the *Sentences* Thomas asks "whether demons can induce a true corporeal effect into corporeal matter." He then lists five authoritative opinions that deny the possibility of such demonic power. The last of

[42] Paul of Taranto, *Theorica et practica* (cit. n. 33), fol. 6v, ll. 18–20: ". . . probaverimus in prefato de libello de causatis et causis naturaliter fieri posse ex quolibet quidlibet citra animatum et animam, scilicet quantum ad formam elementarem, sive mixtorum sive simplicium, ut sunt quatuor elementorum corpora ac lapides et metalla."

[43] Roger Bacon, *In libro sex scientiarum . . . ,* in *Opera hactenus inedita,* Vol. IX, ed. A. G. Little and E. Withington (1928), pp. 183–184. See also Thorndike's comments in *History of Magic and Experimental Science* (cit. n. 40), Vol. II, pp. 628–629.

[44] Aegidius Romanus, *Quodlibeta revisa, correcta, et varie illustrato, studio M. F. Petri Damasi de Coninck* (Louvain, 1646), pp. 147–149 (= *Quaestio* 3, *Quodlibeti* 8, *Membri* 3).

[45] Aquinas, *In meteorologicorum continuatio,* in *Opera* (cit. n. 11), Vol. VII, p. 627, cols. 1 and 2; and Aquinas, *Summa theologiae, ibid.,* Vol. II, p. 623, cols. 2, 3; p. 873, cols. 1, 2. See also Francesco Migliorino, "Alchimia lecita e illecita nel Trecento: Oldrado da Ponte," *Quaderni Medievali,* 1981, *11*(June):33.

[46] Thomas Aquinas, *In quatuor libros sententiarum,* in Aquinas, *Opera,* Vol. I, p. 145, cols. 1–3. On the probable date of composition see William O. Wallace and James Weisheipl, "Thomas Aquinas," in *The New Catholic Encyclopedia,* Vol. XIV, p. 104.

these is the *Sciant artifices*: "Demons cannot work except through the method of art. But art cannot give a substantial form, whence it is said in the chapter on minerals that the authors of alchemy should know that species cannot be transformed. Therefore neither can demons induce substantial forms."[47]

Thomas next defines legitimate art as a procedure that merely joins passive natural products to active natural powers in order to produce a required effect. A good example, Thomas says, is the lighting of a fire. The artisan conjoins the form of fire (the natural agent) and the wood (the passive material) in order to draw forth the effect of fire. Demons act in the same way: they "cannot produce new effects by creation," like God himself; they can only apply natural agents to natural patients. When demons appear to raise the dead or perform other supernatural acts, they are acting by means of illusion only; the effects of such illusion are false and ephemeral.

Thomas returns to alchemy at the end of this distinction, in order to buttress his earlier comments.

> Art by its own power cannot confer a substantial form, but it can do this by means of a natural agent, as is clear in the following [*hoc*], that the form of fire is produced in logs through art. There are some substantial forms, however, which art cannot induce by any means, since it cannot find the proper active and passive subjects. Even in these art can produce a similitude, as when alchemists produce something similar to gold as to exterior accidents. But it is still not true gold, since the substantial form of gold is not [induced] by the heat of fire—which alchemists use—but by the heat of the sun in a determinate place where the mineral power flourishes. Hence such [alchemical] gold does not operate according to the species [of real gold], and the same is true for the other things that they [alchemists] make.[48]

Thus it is impossible for the alchemist to join the form of a precious metal to the substance of a base one in the way that the form of fire is joined to wood, because this must be done deep within the earth, where the mineral power or *virtus* is subjected to a special strengthening. For the same reason, Thomas adds, "the other things that they [alchemists] make" must also be deficient when compared with their naturally occurring counterparts. Thomas therefore rejects not only the alchemical creation of metals but the artificial synthesis of any chemical product. Such "alchemical" substances as ammonium chloride produced by the destructive decomposition of hair, or copper acetate made with vinegar left in a copper flask, are implicitly rejected as "fake" because they were not generated in the bowels of the earth, "where the mineral power flourishes." A form of this

[47] Aquinas, *In quatuor libros sententiarum,* p. 145, col. 1: "Utrum daemones possint inducere in materia corporali verum effectum corporalem. . . . Praterea, daemones non operantur nisi per modum artis. Sed ars non potest dare formam substantialem; unde dicitur in cap. de *numeris*: sciant auctores alchimiae, species transformari non posse. Ergo nec daemones formas substantiales inducere possunt." The text used by Busa contains a manifest error: *numeris* should be corrected to *mineris*.

[48] *Ibid.*: "Ad quintum dicendum, quod ars virtute sua non potest formam substantialem conferre, quod tamen potest virtute naturalis agentis; sicut patet in hoc quod per artem inducitur forma ignis in lignis. Sed quaedam formae substantiales sunt quas nullo modo ars inducere potest, quia propria activa et passiva invenire non potest, sed in his potest aliquid simile facere; sicut alchimistae faciunt aliquid simile auro quantum ad accidentia exteriora; sed tamen non faciunt verum aurum: quia forma substantialis auri non est per calorem ignis quo utuntur alchimistae, sed per calorem solis in loco determinato, ubi viget virtus mineralis: et ideo tale aurum non habet operationem consequentem speciem; et similiter in aliis quae eorum operatione fiunt."

argument had already been rebutted by the *Book of Hermes,* where the pseudonymous author relied on the empirical testing of artificial reagents to confirm their equivalence to the natural forms. Furthermore, the *Book of Hermes* used the artificial incubation of chicks to disprove directly the necessity of a special *virtus loci* (a power linked to a certain place).[49]

In the work of Giles of Rome these rather incidental comments of Thomas are fleshed out to become a full-fledged attack on alchemy. Like Thomas, Giles relies on the *Sciant artifices* and the argument that the generation of metals requires a specific *virtus loci,* a mineralizing power found only deep within the earth. Similarly, Giles, like Thomas, does not consider alchemy in the context of natural philosophy—although he too wrote commentaries on *De generatione et corruptione* and the *Meteorologica*—but in his *Quodlibeta,* a treatise concerned primarily with theology. Furthermore, the question "whether man can make gold" belongs to the subsection of the *Quodlibeta* devoted to the subject of man, and here man is being treated "in relation to his art," not "in relation to nature."[50]

Giles's *quaestio* actually contains two questions: first, "whether man can make true gold by art," and second, "given that he can make gold, whether it be permissible to sell such gold." Relying on the *Sciant artifices,* Giles paraphrases Avicenna's argument that nature is better than art, saying that art is only a principle of artificial things, whereas gold is not artificial but natural.[51]

Then Giles introduces the argument of the *virtus loci.* Admitting that some creatures, such as the bees generated spontaneously from dead cattle, do not need a specific place of generation but only a "material principle" (putrefying matter), he argues that other things, such as wine made from grapes, need both this material principle and a specific place of generation, for wine is produced only "in the depth of the grape" (*in ventre vitis*). Similarly, Giles says, "it is also believable" that metals must be generated deep within the earth.

The second question, "given that man can make gold, whether it is permissible to sell such gold," Giles refuses to entertain seriously, since he is unequivocally convinced that artificial gold cannot be made. At this point he reveals the true nature of his argument, saying that even if gold that would withstand the assayer's test of cupellation could be made, it would still not be legal tender, since it would not have all the medical properties of natural gold.[52] It follows that such a product would not be real gold, despite the assayer's judgment. No doubt Giles would have said the same even if such artificial gold had the same specific weight as natural gold, for to him, mineral gold and artificial gold can *never* be the same, regardless of their properties. Like Avicenna, Giles has adopted the immutable principle that artificial products can never be the same as their natural models.

The last three decades of the thirteenth century witnessed an increasingly hostile attitude by religious authorities toward alchemy that culminated eventually in the denunciation *Contra alchymistas,* written by the well-known inquisitor Nicholas Eymeric in 1396. Giles's attack was preceded, for example, by a number

[49] *Liber Hermetis* (cit. n. 18), p. 66: "Loci oppositio cassatur quia sicut ex ovo in ventre animalis nascitur, sic etsi sub mamilla vel in fumario ponitur, animalis nascetur."

[50] Aegidius Romanus, *Quodlibeta* (cit. n. 44), p. 147.

[51] *Ibid.*

[52] *Ibid.,* p. 149.

of interdictions issued by the religious orders; the Dominicans alone propounded condemnations of alchemy in 1272, 1287, 1289, and 1323. The movement to prohibit alchemy was given papal authority in 1317, when John XXII issued his well-known bull "Spondent quas non exhibent,"—after he had held a public disputation between alchemists and their detractors, according to Eymeric. This papal document is directed specifically against alchemists who employ their artificial gold for counterfeiting; it was motivated by purely fiscal reasons, for the debasement of coin by counterfeiters, alchemical or otherwise, presented a serious problem to the medieval commonwealth. It thus contains little theoretical justification. Nonetheless, the bull does say that the alchemists feign "that which is not in the nature of things," indicating that John did not believe alchemical transmutation to be physically possible.[53]

What was the reason for this great backlash against alchemy that seems to have begun around the time Paul of Taranto was writing his *Theorica et practica*? We have already suggested that the alchemical proponents were themselves in part responsible, by arrogating too much power to the claims of their art. Yet deeper causes were at work. These are evident even in a well-known *consilium* by the consistorial advocate Oldrado da Ponte, probably written in the first decade of the fourteenth century. Oldrado's *consilium* in fact includes passages in support of alchemy. The opening contains a quotation from the ninth- or tenth-century *Canon Episcopi,* a document intended to prohibit belief in witches, who, according to certain old pagan beliefs, could assume monstrous shapes.[54] First Oldrado quotes the part of the *Canon Episcopi* he intends to refute: "[It seems] that the art of alchemy should be prohibited, because the *Canon Episcopi,* question 26, 1, says that 'whoever believes that anything created [*creaturam*] can be either mutated or transferred into another species or into another similitude, except by the creator Himself, is an infidel, and worse than a pagan.' "[55] It is peculiar that Oldrado should have taken a document that originally had no concern with alchemy to apply directly to that art. Is it possible that others, seeing a similarity of language between the *Canon Episcopi* and the *De congelatione,* had preempted him in this regard? If one inspects the passage above without respect to its original context, it could indeed seem to be a sort of official decree of the message propounded by the *Sciant artifices*. The passage explicitly states that only God himself can transmute species, and that anyone who believes otherwise is not a Christian.

Oldrado's response to the *Canon Episcopi* is also revealing. Instead of replying that this edict has nothing to do with alchemy, he answers in the following manner: "[Alchemists] do not say that one species is mutated into another (as is imputed to them), because this is not possible. But they say that one species of metal (such as gold) can be produced from another species of metal (such as tin)."[56] Oldrado's rebuttal does not maintain that specific transmutation is possi-

[53] Halleux, *Textes alchimiques* (cit. n. 8), pp. 124, 126–127, 126 n. 30; C. Narbey, "Le moine Roger Bacon, et le mouvement scientifique au XIIIe siècle," *Revue des Questions Historiques,* 1884, *35*:157; and Migliorino, "Alchimia" (cit. n. 45), p. 16, n. 32 (on Eymeric).

[54] Norman Cohn, *Europe's Inner Demons: An Enquiry Inspired by the Great Witch Hunt* (London: Chatto, Heinemann, for Sussex Univ. Press, 1975), pp. 210–211.

[55] Oldrado da Ponte, *Consilium 74, de sortilegia, num. I,* in Fanianus, *De iure artis alchemiae* (cit. n. 3), p. 211.

[56] *Ibid.*

ble; he points out instead that the species of the metal is not transmuted, but only the metal itself. The origin of this strange-sounding claim was probably a late thirteenth-century alchemical work ascribed spuriously to Roger Bacon, the *Breve breviarium*. It is quite likely that the author of the *Breve breviarium* originated this defense himself, as it seems to be developed at greater length here than in any other medieval alchemical text. By claiming that the species of the metals are not transmuted, but only the metals themselves, the *Breve breviarium* means that the group of characteristics that make silver silver (its argenteity) and gold gold (its aureity) do not change if an individual piece of silver is transmuted into an individual piece of gold.[57] Gold will still be defined, for example, as a "yellow, soft, malleable, fusible, heavy, body," and silver as a "white, soft, malleable, fusible body, of moderate weight." Nonetheless, an individual piece of silver can be physically transmuted so that its matter will conform to the definition of gold. Hence, the physical characteristics of the individual piece of silver will have been changed to the degree that they now belong to the species of gold.

Oldrado's *consilium,* although taking the same approach as the *Breve breviarium,* differs from that text in its motivation. While the *Breve breviarium*'s argument seems to be directed solely against the *De congelatione,* Oldrado is responding to the *Canon Episcopi,* which explicitly said that only God could transmute species. Oldrado's response is therefore intended to bear the onus of doctrinal correctness, whereas the *Breve breviarium*'s—at least overtly—is not. We have already seen Thomas Aquinas and Giles of Rome treat alchemy in a theological context, where Thomas even mentioned alchemists in the same breath as demons. Like Thomas and Giles, Oldrado sees alchemy in a theological light, while the defenders of alchemy had focused merely on its naturalistic implications. This growing tendency to theologize the issue of alchemy, I propose, provides the main reason for the increased number of condemnations tendered against it during the late thirteenth and fourteenth centuries. We should not forget that Innocent III and Gregory IX had already established the papal Inquisition in the first half of the thirteenth century, and that by the second half that dreaded institution was "fully organized."[58] Oldrado's need to answer to the *Canon Episcopi* was not necessarily an anomaly: it may well have reflected the obsession with heterodoxy that had begun with the Albigensian Crusade and eventually resulted in the witch hunts of the sixteenth and seventeenth centuries.

Despite the efforts of Giles, John XXII, and later Nicholas Eymeric, Latin alchemy could not be wiped out by proclamation or other official means. The

[57] Pseudo–Roger Bacon, *Breve breviarium,* in *Sanioris medicinae magistri D. Rogeri Baconis Angli de arte chymiae scripta* (Frankfurt, 1603), pp. 123–126, on pp. 125–126: "Sic revera species non mutantur, sed individua: et sic illud intelligitur . . . species ergo argenti, quae est argenteitas non permutatur in speciem auri, quae est aureitas; quoniam species vere permutari non possunt, quia non sunt subiectae per se accretionibus [*sic codex;* MS Oxford, BL, Digby 119, fol. 66r, *leg.* actionibus *ut vid.*] sensibilibus, nec in se compositionem partitam habent, vel contrariam, quae sit causa permutationis vel subiectum. . . . Ex hoc argentum vel aurum factum est subiectum alterius speciei, quam alia complevit et induxit materiae purgatio atque digestio." The text of the *Breve breviarium* exists in fragmentary form in a manuscript that, according to oral communication from M.-Th. d'Alverny, derives from the late 13th century (MS Paris, BN, Lat. 6514, fols. 126–129). The inauthenticity of the ascription seems assured by the text's dependence on Albertus Magnus's *De mineralibus* for the theory that sulfur and other reagents contain a three-fold humidity (pp. 110, 165, etc.). For a description of this theory, and Albert's source, see Newman, "The *Summa perfectionis*" (cit. n. 14), Vol. III, pp. vii–xi.

[58] Cohn, *Europe's Demons* (cit. n. 54), p. 24.

vision of human power in the realm of technology raised by the *Book of Hermes,* Roger Bacon, and Paul of Taranto was too seductive to be repressed for long. The role of Hermetic literature in the message of such propagandists for the "dignity of man" as Pico della Mirandola is now well documented. Alchemy's place in shaping the reformatory vision of Paracelsus (d. 1541) cannot be overstated. The same may be said for the "archimage" of the sixteenth century, Cornelius Agrippa von Nettesheim, while the technological apologist John Dee, whose *Mathematicall Preface* of 1570 demonstrated the practical application of Euclid's *Elements,* was heavily indebted to the corpus of Roger Bacon, including a number of spuriously attributed alchemical works.[59]

[59] Frances Yates, *Giordano Bruno and the Hermetic Tradition* (London: Routledge & Kegan Paul, 1964); Walter Pagel, *Paracelsus: An Introduction to Philosophical Medicine in the Era of the Renaissance* (Basel: Karger, 1958); William Newman, "Thomas Vaughan as an Interpreter of Agrippa von Nettesheim," *Ambix,* 1982, *29*:125–140; Nicholas Clulee, "John Dee's Mathematics and the Grading of Compound Qualities," *Ambix,* 1971, *18*:178–211; and Clulee, "Astrology, Magic, and Optics: Facets of John Dee's Early Natural Philosophy," *Renaissance Quarterly,* 1977, *30*:632–680. Both articles by Clulee give ample witness to the heavy influence of Roger Bacon. Dee also owned a

APPENDIX: TEXT OF PAUL OF TARANTO'S DISCUSSION OF THE TYPES OF HUMAN TECHNOLOGY

Que naturalia etiam dicuntur materia intellectus vel artis et que artis instrumenta dicuntur
Primum Capitulum *[2r]10*

Cum igitur sub arte sumantur naturalia entia ut nove forme per artificium imprimantur in eis, tunc ipsa naturalia / que transmutantur ac formas ipsas recipiunt *15*
dicuntur materia intellectus vel artis. Entia vero quibus mediantibus aut aliquo modo agentibus imprimuntur ipse forme in id quod eas suscipit artis instrumenta dicuntur. Terminatur autem sic opus artis ad formam duplicis generis, nam aliquando ad / formam extrinsecam ut in arte pingendi, sculpendi, domificandique et *20*
similibus, et hec forma dicitur proprie forma artis, et aliquando terminatur opus artis ad formam substantialem intrinsecam, ut agricultura et medicina, et hec forma dicitur forma nature. Hec autem differentia surgit a / differenti modo su- *25*
mendi naturam ut instrumentum, cum enim instrumentum sit de genere activorum, activum autem in natura sit aliqua virtus eius, necesse est ut natura dicatur sumi per aliquam suam virtutem, cum sit instrumentum operationis sub arte. Et quoniam virtus nature que sit sumi // potest se habere duobis modis, ideo con- *[2v]*
tingit per eam dari formam duobus modis dictis alterius nature subiecte. Est enim omnis virtus in natura quedam qualitas. Qualitates autem naturales quedam dicuntur prime, que sunt differentie / naturales in quatuor corporibus simplicibus *5*
primis scilicet elementis. Et hec forme sunt ille quatuor qualitates principales ad omnia nature opera, videlicet calidum, frigidum, siccum, et humidum, que sunt in secunda specie qualitatis, que dicitur potencia naturalis. Alie vero naturales /

Foliation and lineation of the Latin text are derived from MS Paris, Bibliothèque Nationale, Latin 7159, fols. 1–55r, and replicated in William Newman, "The *Summa perfectionis* and Late Medieval Alchemy" (Ph.D. diss., Harvard Univ., 1986). For descriptions of the manuscripts and their families see *ibid.*, Vol. III, pp. 1–7. The manuscript sigla are as follows (this section does not appear in *Z* = Paris, Bibliothèque Nationale, Latin 14005):

P = Paris, Bibliothèque Nationale, Latin 7159. *A* = London, British Museum, Additional 10764.
M = Manchester, John Rylands Library, Latin 65.

10–12 Que . . . capitulum *om. A* 10 vel] tractatus vel *P* 12 Primum *ego;* Primo

My purpose in this essay has not been to prove the continued influence of alchemy on the development of applied science and technology throughout the Scientific Revolution, but merely to show that here, in these obscure treatises of the thirteenth century, a propagandistic literature of technological development was born. During this innovative period, alchemical writers and their allies produced a literary corpus that was among the earliest in Latin to promote actively the doctrine that art can equal or outdo the products of nature, even if human art is learned by imitating natural processes. Similarly, these alchemical propagandists—or at least the bolder among them—did not shy away from the conclusion that man can even change the order of the natural world by altering the species of those products. This technological dream, however premature, was to have a lasting effect on the direction taken by Western culture.

number of important alchemical manuscripts, such as Oxford, BL, Digby 119, and Glasgow, Hunterian 253. Of the manuscripts listed in Dorothea Waley Singer, *Catalogue of Latin and Alchemical Manuscripts in Great Britain and Ireland* (Brussels: Maurice Lamertin, 1928), at least one contains works ascribed to Bacon with notes by Dee: London, BM, Sloane 2327, fols. 30r–v and 36r–38r.

APPENDIX: TRANSLATION

Which natural things are called the matter of intellect or art, and which are called the instruments of art

Therefore, since natural things are appropriated by art so that new forms be impressed in them through artifice, the natural things that are transmuted and receive the forms are themselves called the matter of intellect or art. But the entities by whose mediation or action these forms are impressed into that which receives them are called the instruments of art. Yet the work of art is restricted to a form of double genus as follows: sometimes [it is restricted] to an accidental, extrinsic form, as in the art of painting, sculpting, house building, and the like, and this form is properly called a "form of art"; and sometimes the work of art is restricted to a substantial, intrinsic form, as in agriculture and medicine, and this form is called a "form of nature." But this distinction arises from the different way of taking nature as instrument, for since an instrument is of the genus of "active things," but an active thing with regard to nature is some virtue of it [i.e. nature], it is necessary that nature be said to be taken through some virtue of itself, since it is the instrument of operation under art. And since the virtue of nature that is to be taken [2v] can exist in two manners, it therefore happens on account of it [the virtue] that the form of the other subjected nature [i.e., nature as matter] exists in the two said manners. For every virtue in nature is a certain quality. But certain natural qualities—which are the natural differences in the four first simple bodies, namely, the elements—are called "primary." And these forms are those four principle qualities [sufficing] for all the works of nature, namely, hot, cold, dry, and wet, which are in the second species of quality, which is called "natural capacity."[a] The other natural qualities are called secondary qualities, namely, those

[a] The second "species of quality" (*potencia naturalis*) belongs to a fourfold division of qualities that is derived ultimately from Aristotle, *Categories* 8b26–10a16.

PM 13 entia] etiam *P* 14 ipsa *om. M* 17 id] his *A* 18 suscipit] recipit *A* 23 agricultura] in agricultura *MA* 25 sumendi] resumendi *M* 28 suam] sui *M* 29 que sit] sicut *M* que sic *A*

2 subjecte] subjectis *M* 4 prime] proprie que sunt] proprie quedam *M* 6 hec *om. M* 7 videlicet] scilicet *M* 9 potencia passio *P*

qualitates dicuntur qualitates secunde, a primis scilicet causate, ut album, nigrum, dulce, amarum, durum, molle, acutum, obtusum, que sunt in tertia et quarta specie qualitatis, per passibilem qualitatem et per figuram. Cum igitur ars sumit pro instrumento nature virtutem que de genere / est secundarum qualitatum, ut se habet color in picturis vel figura anguli vel scabelli durities vel dolabre in sculpturis et dolacionibus sive similibus, tunc necesse est extrinsecus formam accidentalem induci, cuius ratio ista est: ars et artifex ex extra se habent ad patientem naturam in quam agunt. / Secunde autem qualitates predicte de se proprie active non sunt in naturam aliquam nisi per accidens, proprie enim de se sunt active in sensum per suas species secundum esse spirituale et intentionale quod habent, et non secundum eorum esse naturale, nisi per accidens. Color enim movet visum / secundum esse intentionale quod habet in perspicuo et non secundum esse naturale quod habet in re nature, et sapor ut sapor movet sensum et non naturam de se ex simili ratione, neque et sapor nutrit sed cibus et potus, scilicet aliqua substantia cuius // est sapor, unde sapor in naturam non agit nisi per aliud [3r] —scilicet calidum, frigidum, siccum, et humidum—que sunt in re saporosa. Neque aliqua secundarum qualitatum agere potest intra naturam et essentiam alicuius, nisi per qualitates / primas. Igitur quoniam ars et artifex sunt extra res patientes, et natura que sumitur ut instrumentum de se non est transmutativa substantie, nec ista accidentia sunt per se sed per accidens, nunquam ars opus terminare poterit nisi ad formam accidentalem ex extra. Cum vero ars sumit pro / instrumento nature virtutem que est de dictis qualitatibus primis, necesse est opus ad substantiam vel ad substantialia terminari, quoniam calidum, frigidum, siccum, et humidum sunt quasi manus nature et principales eius virtutes, per quas natura cuncta generabilia transmutat et facit. Et ars tunc / est proprie solum in ratione moventis et dirigentis, adminiculantis atque regentis, non autem in ratione facientis. Ipsa vero natura tunc se habebit ratione moventis, facientis, sive causantis, secundum quod Aristoteles in libro de generatione innuit distinctionem moventis, cuius est influere / formam motus, et facientis, cuius est influere formam rei per formam motus. Hinc est igitur quod in medicina terminatur ars ad formam nature que est dispositio complexionis intra, et in agricultura similiter ut est germen et fructus, qui non habentur nisi per cultum, sicut in hortis et in insertionibus / arborum et in agriculture similibus. Quoniam autem hi sumunt ipsa naturalia agentia et non solum nature materiam et passiva accidentia pro instrumento—sumit enim agricultor pro instrumento terram, aquam, aerem, calorem, et semina, et medicus similiter specierum virtutes—ideo essentialia // faciunt tales et [3v] non solum accidentalia, per virtutem et operationem nature. Et in omnibus quoniam natura facit, et ars solum ministrat coaptatque regitque, debet quidem effectus tribui potius nature quam arti, vel nature sub arte.

10–11 scilicet causate] quatuor causari *M* 12 specie] proprie *A* 16 scabelli] scalpelli *MA* 17 sive] vel *M* est *om. P* 19 ex *om. M* 20 proprie] prime *M* 20–24 proprie . . . accidens *om. A* 24 *post* naturale *add.* naturaleque *PM* 28 neque et] neque enim *M* 29 aliqua substantia] a quo substantiatus *M*

2 calidum] per calidum *MA* 3 Neque] atque *P* 7 per se sed] nisi *M* 8 nunquam] non quam *A* 9 ex *om. A* 10 de] ex *M* 13 et principales] principalesque *M* 15 solum] sola *A* 15–17 et . . . moventis *om. A* 16 adminiculantis] adminiculi *M* 18 sive causantis] causatis *P* 19 distinctionem] distinctionis *P* n 20 facientis] faciens *A* 24 et in insertionibus] et insertionibus *MA* 25 agriculture] agricultura *M* similibus] et similibus *M* 27 enim] ergo *M* 29 virtutes] virtutes pro primo esse *M* ideo essentialia] naturalia *M*

4 nature] melius nature *MA*

caused by the first, such as white, black, sweet, bitter, hard, soft, sharp, dull, which are in the third and fourth species of quality, through their ability to produce an affection,[b] and through [their having] figure [and shape].[c] Therefore, when art takes as instrument a virtue of nature that is of the genus of secondary qualities, such as color is held [to be] in pictures, or the figure of an angle, or the hardness of a knife, or pickax, in sculptures and carvings or the like, then it is necessary that an accidental form is extrinsically induced. The reason is as follows: art and artificer [in this case] are extrinsically related to the passive thing, nature, on which they act. But the foresaid secondary qualities do not of themselves properly act on any nature except accidentally, for of themselves they properly act on sense alone, through their own species, according to the spiritual and intentional being that they have, and not according to their natural being, except accidentally. For color moves the sight according to the intentional being that it has in the *perspicuum,*[d] and not according to the natural being that it has in the matter of nature; and flavor qua flavor moves the sense and not nature of itself, from a similar cause, nor does flavor nourish, but food and drink, namely, some substance that [3r] has flavor. Whence flavor does not act on nature except through something else—namely, hot, cold, dry, and wet—which are in the flavorful thing. And none of the secondary qualities can act on the nature and essence of anything else, except through the primary qualities. Therefore, since art and artificer are [in this case] external to the passive things and the nature that is taken as instrument is not of itself transmutative of substance, nor are these accidents [transmutative] *per se* but *per accidens,* art will only be able to lead its work as far as an external accidental form. But when art takes as an instrument the virtue of nature which is of the said first qualities, the work must extend as far as substance or substantial things, since hot, cold, dry, and wet are as it were the hands of nature and her principal virtues, through which nature transmutes and makes all things that come into being. Art, then, properly acts only by moving, directing, aiding, and ruling, but not by making. But nature herself behaves by moving, making, [and] causing, about which Aristotle intimates, in *De generatione et corruptione,* the distinction of the moving, whose [role] is to infuse the form of motion, and of the making, whose [role] is to infuse the form of the thing through the form of motion. Hence it is, therefore, that in medicine art is limited to the form of nature that is the disposition of a complexion within, and similarly in agriculture, as it is [in the case of] the seed and fruit that are not had except by cultivation, as in gardens, and in graftings of trees, and in similar agricultural matters. But since these men take up natural agents themselves as instrument, and not only the material and passive accidents of nature—for the agriculturist takes as instrument earth, water, air, heat, and seeds, and the doctor likewise the virtues of drugs —therefore [3v] such men make essential [changes] and not only accidental ones, [although] through the virtue and operation of nature. And since nature in all things makes, and art only administers, joins, and rules, the effect must surely be attributed to nature rather than to art, or to nature under art.

[b] I have translated *per passibilem qualitatem* as "through their ability to produce an affection." See Roy J. Deferrari et al., *A Lexicon of Thomas Aquinas* (Baltimore: John D. Lucas, 1948), under "Passibilis" and "Qualitas."

[c] See Aristotle, *Categories,* 10a11–16.

[d] The *perspicuum* is the transparent medium postulated by Aristotle in *De sensu et sensilibus* (Venice, 1572), p. 8.