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things which, though
ly separated by it. For
e is found without sur-
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al thing these three are
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a mathematical object
l exist as such in reality,
en considers actual as-
re but as they can exist[27]
ıselves, but with respect
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ı derives the axiom that
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man Readings, Book II,
Isidore's *Etymologies*,
)h 16, Taylor declares (p.
)f this phrase to geometry
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chapter 25.
n Aristotle's conception of
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n and Corruption II.3.330b.
d translation by Harold
nd each of the bodies we

Nor ought we to overlook the fact that physics alone is concerned properly with things, while all the other disciplines are concerned with concepts of things. Logic treats of concepts themselves in their predicamental framework, while mathematics treats of them in their numerical composition. Logic, therefore, employs pure understanding on occasion; whereas mathematics never operates without the imagination, and therefore never possesses its object in a simple or non-composite manner. Because logic and mathematics are prior to physics in the order of learning and serve physics, so to say, as tools—so that every person ought to be acquainted with them before he turns his attention to physics—it was necessary that these two sciences base their considerations not upon the physical actualities of things, of which we have deceptive experience, but upon reason alone, in which unshakeable truth stands fast, and that then, with reason itself to lead them they descend into the physical order.[29]

Having therefore already shown how Boethius's division of theoretical science fits in with what I gave just before, I shall now briefly repeat both divisions so that we may place their terminologies side by side and compare them.

17 CLASSIFICATION OF THE SCIENCES

Domingo Gundisalvo (fl. 1140)

Translated by Marshall Clagett and Edward Grant[1]

Annotated by Edward Grant

PROLOGUE

. . . . . .

. . . Since there is no science which is not some

have mentioned, are not simple, but blended. The 'simple' bodies are indeed similar in nature to them, but not identical with them. Thus the 'simple' body corresponding to fire is 'such-as-fire,': not fire: that which corresponds to air is 'such-as-air': and so on with the rest of them. . . ." William of Conches (*On the Philosophy of the World* [*De philosophia mundi*], Bk. I, ch. 21), for example, explicitly denied that the fire, earth, air, and water which we see are actually elements; they are already compounded. See Selection 17, n. 9, and Selection 109.2, n. 10.

29. A Platonic conception in sharp opposition to Aristotle's attitude toward experience.

30. Taylor comments (p. 204, n. 62) that "instead of 'philological' one would expect 'physiological' in the sense defined in II.xvi." But he observes that the term *phylologia* was at times used for physics.

CHAPTER 18

COMPARISON OF THE FOREGOING

The theoretical is divided into theology, mathematics, and physics; or, put differently, into intellectible, intelligible, and natural knowledge; or still differently, into divine, "instructional," and philological.[30] Thus, theology is the same as the intellectible and the divine; mathematics as the intelligible and the "instructional"; and physics as the philological and the natural.

There are those who suppose that these three parts of the theoretical are mystically represented in one of the names of Pallas, fictional goddess of wisdom. For she is called "Tritona" for *tritoona*, that is, threefold apprehension of God, called intellectible; of souls, called intelligible; and of bodies, called natural.[31] And the name of wisdom by right belongs to these three alone: for although we can without impropriety refer to the remaining branches (ethics, mechanics, and logic) as wisdom, still these are more precisely spoken of as prudence or knowledge—logic because of its concern for eloquence of word, and mechanics and ethics because of their concern for works and morals. But the theoretical alone, because it studies the truth of things, do we call wisdom.[32]

31. Taylor cites (p. 204, n. 63) virtually the same threefold distinction by Remigius of Auxerre (d. 908) in his commentary on Martianus Capella's *Marriage of Mercury and Philology*.

32. Taylor says (p. 205, n. 64): "The present exclusion of logic, ethics, and mechanics from wisdom is at variance with *Didascalicon* II. 17, where Hugh associates logic with mathematics and physics as concerned, though on different levels, with *things*, and with *Didascalicon* I. 8, where Hugh, arguing from premises carefully laid down in earlier chapters of Book I, demonstrates that both practical and mechanical arts must be taken as parts of wisdom."

1. Translated from Dominicus Gundissalinus, *De divisione philosophiae*, edited by Ludwig Baur in *Beiträge zur Geschichte der Philosophie des Mittelalters*, Texte und Untersuchungen, Band IV, Heft 2–3 (Münster Westfalen: Aschendorffsche Verlagsbuchhandlung, 1903), pp. 5–35, 69–72, 74–77, 82–88, 90–94, 103–124. Many of the sources used by Gundissalinus (hereafter cited as Gundisalvo, the Spanish form of his name) were identified by Baur.

part of philosophy, we should first see, therefore, what philosophy is and why it is so called; then what is its purpose and end; then what are its parts and the parts of its parts; finally, what should be considered about each of them.

Philosophers have described philosophy in two ways. One of these is by its properties, the other by its effects. That which has been expressed by its properties is this: "Philosophy is the assimilation of man to the works of the Creator according to the power *(virtutem)* of man." Assimilation to the works of the Creator is indeed the perception of the truth of things, namely the true understanding of them and of their operation, which conforms to the truth. The perception of the truth of things, furthermore, is the perception of these things from the four natural causes: the material cause, the formal cause the efficient cause, and the final cause. . . .[2]

Philosophy is likewise described thus: "Philosophy is the cognition of human and divine things joined with a zeal for living well." Also: "Philosophy is the art of arts and the discipline of disciplines."[3] A description of philosophy taken from its effect is this: "Philosophy is man's total cognition of himself."[4] This is because when a man recognizes himself completely, indeed he recognizes everything that exists *(est)*. For in man there are substance and accident, but substance is twofold: namely spiritual, like soul and intelligence, and corporeal, like a long and wide and thick body.

Similarly accident is twofold: spiritual and corporeal. Spiritual accident is like knowledge and virtue and whatever exists in the soul. Corporeal accident in truth is like "whiteness" and whatever, exists in the body. When a man knows himself perfectly, then he knows whatever exists, because he knows spiritual and corporeal substance and the first substance created out of the power of the Creator without anything intervening, a substance which is of itself subject to diversity. He also recognizes the first general accident, divided into quantity, quality, and relation, and the other six composite accidents, born from the conjunction of substance with the three simple accidents.[5] When, moreover, he comprehends all these things, then he has certainly comprehended every science which is, and he thus deserves to be called a philosopher.

Having recognized what philosophy is, then, it should be seen why it is so called: "Philosophy is the love of wisdom." For *philos* in Greek is translated *amor* (love) in Latin and *sophia* is translated *sapiencia* (wisdom). Whence philosophy is the "love of wisdom" and a philosopher is called a "lover of wisdom."[6]

. . . . . .

Since we have seen why philosophy is so named, now let us examine its intention. "The intention of philosophy is to comprehend the truth of all things that are, insofar as it is possible for man to do so."[7] But of all things that are, some are from our own work and will—our human works, such as laws, constitutions, religious exercises, wars, and other things of this kind. Others are not from our work or will—such as God, angels, heaven, earth, vegetables, animals, metals, spirits, and all natural things.[8] The totality of all things can be comprehended thus: Every thing which is either comes into being or does not come into being. Everything which has not come into being [is] like God, the Creator of all things: the Father, and the Son, and the Holy Ghost. This is truly eternal, being without beginning and end. Moreover, everything which has come into being is like all creatures. Everything which has come into being either has come "to be" before time, such as *yle* (the principle of matter or first matter) and angelic creatures; or it has come "to be" with time, such as celestial bodies, [invisible and pure] elements, and the [visible] elements made by the first composition [of the invisible elements],[9]

2. Although these four causes were formulated by Aristotle, the material in this paragraph was derived from Isaac Israeli's *Diffinitiones,* a work that had been translated from Arabic to Latin.

3. These two definitions are direct quotes from Isidore of Seville's *Etymologies,* Book II, chapter 24 ("On the Definition of Philosophy"), paragraphs 1 and 9.

4. Drawn from Isaac Israeli's *Diffinitiones*. Indeed, this and the next paragraph are from that source.

5. Including substance, these are the ten categories or types of predicates distinguished by Aristotle in his treatise *Categories*. Nine are predicated of substance, which is primary. Quantity, quality, and relation are taken to be more fundamental than the remaining six (place, date, posture, possession, action, and passivity). According to W. D. Ross (*Aristotle,* 5th ed., rev. [London: Methuen, 1949], p. 23), "The categories are a list of the widest predicates which are predicable essentially of the various nameable entities, i.e., which tell us what kinds of entity at bottom they are."

6. This paragraph is also derived from Israeli's *Diffinitiones.*

7. Quoted from the opening line of Avicenna's *Logica,* chapter 1.

8. The last two sentences were taken almost verbatim from the first part of the *Metaphysics* of al-Ghazali (1058–1111), the Muslim theologian who exerted a great influence on the West. See J. T. Muckle's edition of *Algazel's Metaphysics* (Toronto: Institute of Mediaeval Studies, 1933), p. 1, ll. 22–26.

9. ". . .et elementa et elementata ab eis prima composicione." The distinction between the terms elementa

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Artificial things in truth are tho
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and these are everlasting without end; or it has come "to be" after [the beginning of] time, such as all other things. Some of these latter are without end, such as the rational soul; others have an end, such as temporal things *(temporalia)*, which begin in time and cease in time. Some of these temporal things are "natural things"; others are "artificial things." Natural things are those which with the motion of nature visibly operating go forth from potency (potentiality) to act (actuality), such as all living things which are born of the earth, as well as species of beasts of burden. They include also inanimate things which arise from the complexion, composition, or conversion of the elements, or which result from phenomena of the air, like snow, hail, rain, and other things of this kind. Artificial things in truth are those things which are made from the art and will of man, such as *subtellares*.[10] Moreover, there are certain things which are at once natural things and artificial things, such as wine, a statue, a sword, a spike, and similar things. But these are natural things with respect to their matter, artificial with respect to the form which makes them what they are. Spiders' webs, birds' nests, and bees' cells are reckoned among natural things.

Out of these [remarks], then, it has become evident why everything that exists is either from our [human] work and our will or is not from our work but from that of God or nature. Since there is no science which does not have a subject of which it treats, there can be nothing which does not arise from one of these two kinds (that is, of man and nature or God). Hence philosophy in the first place is divided into two parts. One part is that by which we know the dispositions of our works; the other is that by which we know all other things which exist. For there is one part of philosophy which makes us know what ought to be done and this is called "practical" *(practica)*; and there is another which makes us know what ought to be understood and this is "theoretical" *(theorica)*. Therefore, one is in intellect, the other is in effect. One consists in the cognition of the mind alone, the other in the execution of work. For since philosophy has been established in order to perfect the mind *(anima)*, there are two ways by which it achieves this, namely by science [or knowledge *(scientia)*] and operation. Therefore, philosophy, which is the order of the mind *(anime)*, is necessarily divided into *science* and *operation*, just as the mind *(anima)* is divided into sense and reason. *Operation* is relevant to the sensible part and speculation [or *science*] to the rational part. But since the rational part of the mind [or soul] is divided into the cognition of divine things, namely those that are not from our [human] work [or effort], and the cognition of human things, namely those that are from our work [or effort]. Hence the end [or goal] of philosophy is the perfection of the soul, not so that man can know only what he should understand but also so that he may know what he ought to do and [indeed what he] does. For the goal of speculation is the formulation *(conceptio)* of an opinion [or idea] for the understanding [or intellect]; the goal of practice is the formulation *(conceptio)* of an opinion [or idea] for acting.

The parts, therefore, into which philosophy is first divided are theoretical and practical. After this, it remains for us to see what and how many are the parts of these first [two] parts of philosophy. We have said above that theoretical philosophy is the cognition of those things which do not arise out of our work. . . .

. . . . . .

The parts of theoretical philosophy are three: evidently, either speculation [or theory] concerns those things that are not separated from their matters in being *(esse)* or in intellect; or speculation concerns those things that are separated from the matter in intellect but not in being *(esse)*; or speculation concerns those things that are separated from matter both in *esse* and intellect. The first part of this division is called "physical science" or "natural science," which is the first and the lowest; the second is called "mathematical science" or "disciplinal," and is the middle; the third is called "theology" or "the first science" or "first philosophy" or "metaphysics." And because of this Boethius[11] says that physics is unabstracted and with motion, mathematics abstracted and with motion, and theology abstracted and without motion. And these three sciences only are parts of theoretical philosophy in that there can be no more kinds of things other than these three concerning which speculation can be made. Whence Aristotle says:[12] Therefore there are three species of sciences, since one investigates what is moved and corrupted, "natural science"; the second what is moved and not corrupted, the "disciplinal science"; and the

and elementata is discussed in Selection 16, n. 28, and Selection 109.1, n. 10.

10. I have failed to locate this term in the standard sources.

11. *On the Trinity (De trinitate)*, chapter 2.

12. See Selection 16, n. 5.

third considers what is neither moved nor corrupted, "divine science."

Moreover, of this tripartite division, the common utility of theoretical science "is to know the dispositions of all existent things so that in our minds the form of the whole could be described according to its order [or arrangement], just as a visible form is described in a mirror. For such descriptions in the soul [or mind] are the perfection of the soul, since the aptitude of the soul for receiving them is a property of it. Thus the fact that it can be described in the soul is the highest nobility and the cause of future happiness."[13]

But since for the pursuit of future happiness it does not suffice that what is be understood by a single science unless a science of doing what is good follows; therefore practical [science], which is also divided into three parts, follows after theoretical [science].

"One of these is the science of building up one's intercourse with all men."[14] Necessary for this are grammar, poetics, rhetoric, and the science of secular laws, among which is the science of ruling cities and the science of understanding the rights of citizens. This latter science is called "political science" and by Tullius (Cicero) is called "civil reason."

"Second is the science of arranging the home and one's own family. One learns from it how he should live with his wife, children, slaves, and with all his domestics."[15] And this science is called "familiar ordination" *(ordinacio familiaris)* [that is, economics in the Greek sense of the word, or household management—*Ed.*].

Third is the science by which a man perceives how to order his very own way of life according to the honesty of his soul, so that he may be uncorrupted and excellent in his manners. This science is called "ethical or moral science."[16]

. . . . .

And in these six sciences is contained whatever can be known and whatever ought to be done, and for this reason it was said that insofar as it is possible, the intention of philosophy is to comprehend whatever is.

. . . . .

Some truth is known, some unknown. An example of known truth is "Two is more than one" and "Every whole is greater than its parts" and similar statements. An example of the unknown truth is "The world began" and "An angel consists of matter and form" and similar statements which lack proof. Moreover, any thing at all which is unknown does not become known except through something which is known. Therefore, logic is the only science which teaches how by means of the known to arrive at cognition of the unknown. This will be proved later. Wherefore logic naturally precedes all parts of theoretical philosophy and it is necessary to them for the acquiring of truth. But logic indicates the truth by no way except a proposition, and every proposition consists of terms. And furthermore, it is the science of grammar which prepares one for the forming and composing of terms. Therefore, grammar precedes in time logic and all the other sciences. Like a nursemaid it first renders man skillful in speaking correctly.

And thus every science is either a part of philosophy or an instrument, or at the same time a part and an instrument. An example of sciences which are part of philosophy is natural science, or mathematical science, or divine science, as we have said before, while an example of a science as an instrument only is grammar.

But logic is a part and an instrument at the same time. Grammar in truth is an instrument of philosophy as to teaching but not as to learning—for philosophy can be known without words but cannot be taught without them. Logic, however, is in one respect an instrument useful for finding out the truth in itself and in the other sciences, and in another respect is a part of philosophy according as philosophy investigates dispositions (just as it investigates other things) of its subject.

With these three principal parts of theoretical philosophy known—natural, disciplinal, and divine—let us now see what should be investigated concerning each of them. These things ought to be investigated concerning each of the parts: what it is, what is its genus, its matter, its species, its parts, its function *(officium)*, its end, its instrument, who is its artificer, why is it so called, in what order it should be read.

NATURAL SCIENCE

Now, since among all the parts of theoretical philosophy the natural is prior with respect to us,

13. Quoted by Gundisalvo from al-Ghazali's *Metaphysics* (Muckle, p. 2, ll. 4–11).
14. *Ibid.*, ll. 14–15.
15. *Ibid.*, ll. 21–23.
16. Gundisalvo's three practical sciences are in essential agreement with those presented by Boethius in his *Commentary on the Isagoge of Porphyry*, Book I, chapter 3.

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let us inquire about it first.[17] Moreover, what natural science is, is defined thus: "Natural Science is the science considering only things unabstracted and with motion." Every form of matter either can be abstracted from matter or not abstracted. Natural science considers matter simultaneously with form which cannot be abstracted, as was said above; therefore it is spoken of as "unabstracted." But since form, while it is in matter, is always varying, therefore it is said to be "in motion."

Its genus, moreover, is that it is the first part of philosophy, since indeed it is first with respect to us. For we apprehend matter simultaneously with form by the senses earlier than we apprehend form without matter by the intellect.

In truth, "the matter of natural science is body, but not according to what is being *(ens)*, nor according to what is substance, nor what is composed out of the two principles which are matter and form, but rather according to what is subjected to motion and rest and change";[18] for the consideration of body can be made in all these ways which are appropriate to the other sciences that treat of bodies. But natural science does not consider bodies except with respect to what is changed and altered.

But since some of the sciences are universal and others are particular, and, moreover, those are spoken of as universal which contain many other sciences under them, then natural science is universal because eight sciences are contained under it. These are the science of medicine, the science of judgments, the science of nigromance according to physics, the science of images, the science of agriculture, the science of navigation, the science of mirrors, the science of alchemy, which is the science of the conversion of things into other species; and these eight are the species of natural science.

Now there are eight parts of this natural science.[19] The first is a consideration about what all corporeal bodies, whether simple or composite, share, namely with respect to principle and the accidents following upon these principles. And this is taught in the book which is called *On Natural Things That Are Heard (De naturali auditu)*.[20]

The second part is a consideration concerning simple bodies: whether they exist, and if they exist what these bodies are and what is the number of them. And this consideration is about the world *(de mundo)*: what it is and how many parts of it there are and that at most there are three or five [parts]. And this consideration is [also] about the heavens *(de celo)* and its division into the remaining parts of the world and that its matter is one. All this is taught in the first part of the first book of what is called *The Books of the Heaven and the World (Libri celi et mundi)*.[21] Next, a consideration about the elements of composite bodies follows, that is, whether in these composite bodies there are simple bodies whose existence was demonstrated—or bodies other than simple bodies. Now, if simple bodies are in composite [or compound] bodies, it is not then possible that they be outside them. Then [one must consider] whether the whole of these [simple bodies] or [only] parts of them [are in the composite bodies]. If only parts of them, then what would there be of them. This investigation [continues] to the end of the first part of the first book of what is called *On the Heavens and World*. Next there follows a consideration of what all the simple bodies share, [for] some [simple bodies] are elements and principles of compound bodies and some

17. The idea expressed here that the subject matter of natural science is first or prior with respect to us is perhaps traceable to Aristotle's description of the investigation of the principles of physics, or natural science, in *Physics* II.1.184a.15–21:

"Plainly therefore in the science of Nature, as in other branches of study, our first task will be to try to determine what relates to its principles.

The natural way of doing this is to start from things which are more knowable and obvious to us and proceed towards those things which are clearer and more knowable by nature; for the same things are not "knowable relatively to us" and "knowable" without qualification. So in the present inquiry we must follow this method and advance from what is more obscure by nature, but clearer to us, towards what is more clear and more knowable by nature." (Oxford translation by R. P. Hardie and R. K. Gaye.)

18. Despite some minor variations, this passage may be legitimately construed as a quotation from Avicenna's *Metaphysics* (or *De philosophia prima)*, the beginning of Tract I, chapter 2.

19. Although Gundisalvo makes no mention of it, the description of all eight parts given below is virtually a direct quotation from al-Fārābī's *On the Sciences (De scientiis)*, which has been edited by Angel Palencia (*Catálogo de las ciencias*, 2d ed. [Madrid: Instituto Miguel Asín, 1953]) from the Latin translation by Gerard of Cremona (on Gerard's translation, see Selection 7, no. 42; the eight parts are described on pp. 161–163 of Palencia's edition). It is obvious that al-Fārābī based the eight parts of natural science solely on what were judged to be genuine works of Aristotle. In virtue of this, one can see how Gundisalvo's account of the sciences represented the influx of the new learning and how great was the gulf that separated his account from that of Hugh of St. Victor as represented in the preceding selection.

20. This is an alternative title for Aristotle's *Physics*.

21. Aristotle's *On the Heavens*.

are not elements. This investigation is about the heaven and its parts and is taught in the beginning of the second part of the book called *On the Heavens and the World* and continues on for about two-thirds of it. Then there follows a consideration of the properties of the elements and the nonelements both with respect to the principles and the accidents associated with them. This is taught at the end of the second [and all of] the third and fourth books of the *Book on the Heavens and World.*

The third part is an inquiry about the mixture *(permixtione)*[22] and corruption *(corruptione)* of natural bodies generally and of the things of which they are composed and of the quality of the generation and corruption of the elements; and [it is also an inquiry into] how some [things] are generated from others and how composite [or compound] bodies are generated from them [that is, the elements]; and finally *(in summo)* it teaches the principle of all these things. All this is taught in the book called *On Generation and Corruption (De generatione et corruptione).*

The fourth part is an inquiry about the principles of actions and passions that are proper to the elements only without *(sine)*[23] the bodies composed of them. This is contained in the first three parts of the book called *On Phenomena of the Upper Regions (De impressionibus superioribus).*[24]

The fifth part is a consideration of bodies compounded of the elements and of those things [constituted] of similar or dissimilar parts. Of those bodies that are constituted of similar parts there are those which can become parts of different things, as flesh and bone;[25] and there are those which cannot be part of the different parts of a natural body, as salt,[26] gold, and silver.[27] Then consideration follows about what it is that all compound bodies share; next, consideration of what all compound bodies of similar parts share or whether or not they are parts of a compound body of diverse parts. And [all] this is contained in the fourth book of *On Phenomena of the Upper Regions.*

The sixth part is a consideration of what is shared by all compound bodies of similar parts, which are not parts of a compound body of different parts.[28] These are mineral bodies and their species. Then what the properties of these species are is considered next. And all this is taught in the book titled *On Minerals.*[29]

The seventh [part] is a consideration of what species of plants *(species vegetabilium)* share and what the properties of each species are. This is one of two speculative [or theoretical] parts dealing with compound bodies of different parts, and this is taught in the book *On Plants (De vegetabilibus).*[30]

The eighth [part] is a consideration of what species of animals share and what the properties of each species are. And this is the second part of speculation on compound bodies of different parts. It is taught in the book entitled *On Animals (De animalibus),* in the book *On the Soul (De anima),* and in those books which continue to the end of the natural books.

Therefore, the natural science of every species of all bodies gives the four principles and the accidents of these bodies concomitant with those principles. This, then, is the whole of what is in natural science and its parts and the whole of what is in any part of it.

The function of this art is in the contemplation of natural bodies and accidents—for the latter do not have *esse* [or existence] except through these bodies—and it teaches the things from which, through which, and for which these bodies exist.

. . . . . .

And indeed the "matters" and "forms" of bodies and their "agents" and the "ends" through which

22. The corresponding expression used by al-Fārābī is *corruptione et commutatione* (corruption and change).

23. At this point, Baur's edition (p. 22, l. 11) has *et* (and), instead of *sine* (without) as al-Fārābī has it (Palencia, p. 162). It is certain that "without" is intended since the fifth and next part will consider composite bodies while the fourth was to consider only elements.

24. Another title for Aristotle's *Meteorologica.*

25. Flesh and bone are each constituted of similar parts—that is, they are homogeneous—but each can become part of a compounded body as, for example, the arm, which consists of flesh and bone.

26. I have altered Baur's text from *sol* (sun) to *sal* (salt), thereby bringing it into agreement with al-Fārābī's text. It is possible, however, that *sol* was actually intended by al-Fārābī, for it also means "gold" (the alchemist used the term in this way; see Selection 76, n. 13), but then we must explain why he would choose to write *sol et aurum,* using two different expressions for gold.

27. Apparently we are to understand that homogeneous substances in this category do not become components of more complex organic or inorganic bodies.

28. Here only homogeneous bodies such as gold and silver would be considered, because these supposedly are not constituents of more complex compounds involving more than one homogeneous compound.

29. Probably the *Liber de mineralibus* falsely ascribed to Aristotle and discussed in the Introduction to Selection 78.

30. The treatise intended is the pseudo-Aristotelian *De Plantis (On Plants).* The titles *De plantis* and *De vegetabilibus* are synonymous. In al-Fārābī's Latin version it is titled *Liber plantarum.*

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ON MATHEMATICS

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they exist are called the "principles" *(principia)* of bodies. If they relate to the accidents of bodies, they are called "the principles of the accidents which are in bodies."

The "end" of natural science is the cognition of natural bodies. . . . Therefore, this science provides the principles of natural bodies and their accidents. The "instrument" of this science is the dialectical syllogism, which consists of truths and probables. Whence Boethius says: "It is necessary to be versed rationally in natural things."[31] The "artificer" is the natural philosopher who, proceeding rationally from the causes to effect and from effect to causes, seeks out principles. This science, moreover, is called "physical," that is, "natural," because it intends to treat only of natural things which are subject to the motion of nature. Moreover, it is to be read and learned after logic. . . .

ON MATHEMATICS

These same things are also to be sought concerning mathematics. It is defined thus: Mathematics is an abstractive science considering things existing in matter, but without the matter; for example, a line, a surface, a circle, a triangle, and similar things which do not exist except in matter. . . . Whence it is defined by others thus: Mathematics is an abstractive science considering abstract quantity. We call abstract quantity that which we separate from matter in the intellect, or from other accidents—for example: an even number, an odd number, and other things of this kind which we treat by the powers of reason alone.

Now let us see what abstraction is and in how many ways it is done. Abstraction is the apprehension of the form of any kind of a thing whatsoever. "Sense" apprehends form in one way, "imagination" in another, "estimation" (judgment) in a third way, and "intellect" in still another way; for some of them abstract the form of a thing perfectly and others imperfectly. Indeed, those abstract the form of a thing perfectly which apprehend it purely and simply without matter and without all other accidents which are joined in matter. Those abstract the form of a thing imperfectly which apprehend it along with some or several accidents of matter. Thus sight abstracts the form of a thing imperfectly, since it apprehends it only in the presence of matter and with many accidents. Imagination, however, abstracts a little more form from the matter; since form may exist in the imagination itself, it does not require the presence of matter. But, nevertheless, it [the imagination] does not distinguish [or separate] form from all the accidents of matter. Indeed forms are in the imagination only because they are "sensibles," that is, according to quantity, and some quality and position. For imagination cannot imagine form in such wise that all individuals of that species can come together in it (that is, the form). For when a man is imagined, he can be imagined as one man and it is possible that other men are different than the one imagined.

Estimation *(estimatio)* in truth transcends this order of abstraction, since it apprehends nonmaterial intentions which are not in their matters, although they might exist in matter. Figure, color, position, and things similar to these are things which cannot exist except in corporeal matter; while good and evil, licit and illicit, honest and dishonest, and things similar to these are indeed in themselves nonmaetrial things, although it may happen that they are in matter. For if they were themselves material, never would they be understood except in a body, matter being accepted here as corporeal substance. Therefore, when estimation apprehends material things, it abstracts them from matter and it apprehends nonmaterial intentions, even though they might be in matter. And this abstraction is purer and closer to the absolute [form] than the two earlier ones [that is, sense and imagination]. But it does not wholly separate form from the accidents of matter. . . .

But intellect apprehends forms with perfect abstraction, and abstraction everywhere stripped of matter. As for that which is per se stripped of matter, there is no need that it be abstracted from matter for its apprehension. But as for that which does not have any existence *(esse)* except in matter, either its existence *(esse)* is material or this happens to it: by an absolute [or simple] apprehension, intellect abstracts and apprehends it from matter and from all the additions *(appendices)* to matter, just as, for example, happens with "man," which is predicated of many [men]. For thus the intellect apprehends one nature many times and separates it from every quantity, quality, position, and place. Indeed, unless this nature could be abstracted from these things, it would not be appropriate to be predicated of many things. The human form is a nature in which all the particulars of the species come together equally and there is one definition of them. . . . And so [in a similar manner], mathematics is called abstract, since it completely sepa-

31. *On the Trinity*, chapter 2.

rates the things it treats from matter and its accidents. For since it concerns number or figure, it pays no attention to the matter, color, or position of it but considers it absolutely [or simply,] so that [for example] *all* numbers, *all* triangles, and so on, can be embraced equally in a definition.

The genus of mathematics is the second part of theoretical philosophy abstracted from matter and with motion. For however much things are abstracted from matter by the intellect, nevertheless such entities, which cannot exist without matter—and to the extent that they are not in the intellect—are surely not without motion in matter.

The matter of mathematics is universally quantity but considered separately as *magnitude* and *multitude*. It treats most fully those things happening to magnitude and multitude.

Mathematics is also a universal science, since it contains seven arts under it: arithmetic, geometry, music, astrology, the science of aspects, the science of weights, and the science of devices *(ingenia)*.[32] Moreover, the parts of mathematics are four. Magnitude and multitude [constitute the principal divisions], but (1) some magnitude is mobile; (2) some is immobile. Also (3) some magnitude is per se and (4) some is related. Arithmetic investigates multitude per se; while music avows the science of related multitude. Geometry makes clear properties of immobile magnitude; but astrology reveals knowledge of mobile magnitude. . . .

The instrument of mathematics throughout is demonstration. Demonstration, moreover, is a syllogism arising out of primary and true propositions. Some of the primary propositions are things of the senses, such as the following: "Every fire heats," "All snow is white," and similar statements. Some, on the other hand, are things of the intelligence, as "Every whole is greater than its part" and similar statements. Moreover, among the propositions of intelligence of this kind some are primary, some secondary. Primary propositions are those which when first heard are immediately conceded. Moreover, they cannot be the conclusions of syllogisms, for no propositions are better known than they. And therefore they are spoken of as propositions "known per se" because they cannot be made known through other propositions. Whence they are called "common conceptions of the mind." *(communes animi concepciones)*[33]—ones which anybody approves on hearing them. The secondary propositions of the intelligence are those which are concluded from demonstrations. Of this kind are the theorems of Euclid which, after they have been proved through primary propositions, are then assumed in a demonstration. Therefore, they are not known per se [or as self-evident] because they are not known in themselves but through other propositions.

Moreover, there are two species of the demonstrative art, namely geometry and logic. The primary propositions of geometrical demonstration are taken from another art which is prior to it, just as that which Euclid said: "A point is that which has no part," and "A line is length without width," "A surface is that which has length and width." Similarly, the primary propositions of logical demonstration are taken from another art which is prior to it, for example when it is said: "Everything which is, with the exception of God, is substance or accident" and "Substance is that which existing in itself is susceptible to contraries." . . . Furthermore, whoever wishes to be skilled in demonstrations of logic ought first to be trained in geometrical demonstrations because they are closer to the understanding and easier to investigate. This is because the examples are things sensible to the sight, although their intentions are things of the intelligence. . . . The artificer is the demonstrator. The function of this art is to prove in the truest fashion everything that is proposed. Its end is the obtaining of certitude from the ambiguity of a proposed question.

Moreover, this science is called "mathematical," that is, "abstractive", for *mathesis* is interpreted as abstraction. Whence it is said there is no second *mathesis*, that is, second abstraction, since from the things that we once abstract from matter by the intellect we cannot abstract other things once again by the intellect; indeed a form is not abstracted from a form, but from matter. But since this science is about things that are understood abstractly, mathematics is therefore called abstractive.

Mathematics is also called doctrinal or disciplinal *(disciplinalis)*[34]—that is, from a discipline—

32. Gundisalvo includes the traditional quadrivium (arithmetic, geometry, music, and astrology [instead of astronomy]) as part of a now expanded conception of mathematics in which the three additions would be classified as applied mathematics. His division into *magnitude* and *multitude*, with further subdivisions into mobile and immobile, is virtually the same as Hugh of St. Victor's in *Didascalicon* II. 8 (see Selection 16, n. 11).

33. This was the expression commonly used to designate the axioms in Euclid's *Elements*. They were assumed to be self-evident.

34. As used here, a *discipline* is something productive of certain knowledge.

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ON LOGIC[35]

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because those who are disturbed by different opinions in the preceding sciences find that mathematics. . .holds one opinion only, which is proved by demonstration. . . .

Moreover, mathematics should be read after natural science because whoever considers natural science has considered form together with matter, and after completing what pertains to the accomplishments of that science, it is worthwhile that he should know how to consider form without matter until he is [well] accustomed to consider forms without any matter.

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ON LOGIC[35]

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What [Logic] is, is defined thus: "Logic is the doctrine of diligent discussion, that is, the complete science of disputation. . . ." Moreover, the genus of logic is that it is a part and instrument of philosophy. This is shown as follows: Things exist in two ways—sensibly, that is, according as they are subject to the senses, and intelligibly, that is, according as they are conceived by the mind. The following apply to "things according as they are understood": universality, generality, specialty, accidentality, and similar things. For this reason, then, "things according as they are understood" are genera, species, accidents, and similar things.[36] There is nothing of them in sensible things *(sensibilis)*.

Moreover, when we wish to prove or disprove something with regard to either "sensible things" or "intelligible things," it is necessary that we have recourse to those things which occur to intellects, namely genera, species, and so on, so that through them we might prove those things we intend to prove. Every proof or disproof in the whole philosophic art takes place by means of those things which belong to logic alone. Therefore, according to those people who hold that philosophy treats only of two kinds of things, sensibles and intelligibles, logic will be an instrument. But according to those who hold that philosophy also treats of this third mode which occurs to intellects, logic will be a part of philosophy as well as an instrument in the other arts. . . .[37]

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According to al-Fārābī there are eight parts of logic:[38] "categories, interpretation, prior analytics, posterior analytics, topics, sophistries, rhetoric, poetics. [As it can be seen, then], the names of [Aristotle's] works are posited for the names of the sciences which are contained in them. . . . Since the fourth part of logic (posterior analytics) is of greater power, it excels all of the other parts in sublimity and dignity. . . .The remaining parts have been discovered only through the fourth. . . ."

. . . . .

"The sure cognition of truth is not obtained except through demonstration. Therefore, it was necessary that a book be composed in which would be taught how and out of what things demonstration is made. Consequently the book which is called *Posterior Analytics* or the *Book of Demonstration (Liber demonstrationis)* was composed. But since demonstration is made only by means of syllogism and syllogism in truth consists of propositions, it was necessary to have a book in which would be taught the number and kind of propositions, and how according to mode and figure syllogisms should be constructed. For this reason the *Prior Analytics* was written. But propositions cannot compose a syllogism unless they first have been composed out of their own terms. Therefore, it was necessary to have a book which would teach the number of terms and which terms go to make up a proposition. This is fully taught in the work which is called *On Interpretation (Perihermenias)*. Further, a proposition is never well composed from terms unless the signification of each term is first recognized. Therefore, the *Book of Categories (Liber cathegoriarum)* was written to teach how many kinds of terms there are and what is the signification of each of them. . . ."

The species of this art in truth are three kinds of questions: moral, natural, and rational. They are called its species because all of logic is employed in any one of them. The function of this art, according as the art is theoretical, consists in "invention" and "judgment.". . . According as the art is practical, its functions are "division," "definition," and

35. Between mathematics and logic the following sections are omitted here: On Divine Science, On Grammar, On Poetics, and On Rhetoric.

36. These are all concepts in the understanding—that is, "things according as they are understood"—and have no existence in sensible things.

37. In this interpretation, genera, species, accidents, and so on are a third class of things belonging to logic alone and are set by the side of "sensible things" and "intelligible things." Thus, if "things according as they are understood" are construed as part of philosophy, logic will be part of philosophy since this category belongs to logic; if not, logic will be an instrument only.

38. What follows is virtually a quotation from al-Fārābī's *De scientiis* (Palencia, p. 95 ff).

"ratiocination." . . . Ratiocination is the proof or disproof of some doubt. . . . Moreover, ratiocination has three species: (1) dialectical, which is the science of inferring *(colligendi)* through probable things; (2) demonstrative, the science of inferring through things known per se; and (3) sophistic, the science of inferring through things which seem to be true, but are not.

. . . . . .

The principal instrument of this art consists in two things: syllogism and induction. There are two secondary ones which come from them by the subtraction of one or more parts: *enthymeme* and example. . . . The artificer of this art is the disputer, who either topically, demonstratively, or sophistically exercises this art on general questions that are moral, natural, or rational. The "logician," moreover, is he who teaches the logical art, [while] the "disputer" is he who exercises that art. . . .

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Logic therefore ought to be read after rhetoric but in this order: Since the function *(officium)* of logic is to divide, define, and prove, [and since] a proof is not made except by a syllogism, and a syllogism consists of propositions, and propositions of terms, and terms are words signifying some simple understanding, it is [therefore] necessary to understand the simple terms before the things that are composed of them. Hence in the order of logic, the science of terms, which is taught in the *Categories,* is naturally first. Therefore, that book which should be read first is proposed. In it is treated fully the doctrine of simple words, which are the terms of simple enunciations. But since the *Liber introductorius* of Porphyry is for the understanding of the *Categories (Predicamenta),* then it ought to be read before the *Categories.* But after the cognition of terms it remains [for us] to know how the composition of propositions is made from them. Therefore, after the *Categories (Predicamenta)* comes the *On Interpretation,* which ought to be read immediately. In it is taught how a simple enunciation is constituted out of terms. After we learn how to compose propositions out of terms it is necessary that we compose syllogisms from the propositions and do so according to mode and figure. Consequently, we ought to read the *Prior Analytics* after the *On Interpretation.* In it we are taught how a syllogism is composed from propositions. But syllogism has three species: dialectical, demonstrative, and sophistic. Therefore, the *Topics* is read for dialectical syllogism; the *Posterior Analytics* for demonstrative syllogism; and *Elenchi (On Sophistical Refutations)* for sophistical syllogism. It is in this order that Aristotle, the author of Logic, has taught that logic ought to be taught and learned.

ON MEDICINE

But since natural science follows after logic and the first species of natural science is medicine, we must inquire about it all the things stated above, namely:[39] what it is, what is its genus, its matter, its parts, its species, its instrument, who is its artificer, what is its function *(officium)*, its end, why it is so called, what is its use, [and] in what order should it be read.

What medicine is, is shown in this definition: "Medicinal physics is the science of the healthy, the sick, and the inbetween." There are also other definitions according to its function, thus: "Medicine is the science of controlling the natural complexion and of changing that which is foreign (to the body) into the normally existing prior (condition)." Also: "Medicine is that which cares for and restores the health of the human body."

Its genus: it is one of the species of theoretical natural science, for it is unabstracted and with motion.

The matter (subject matter) of medicine is the human body as it becomes diseased and healed. It is through the body that medicine itself has been discovered and on it that medicine is exercised. This science treats of three things: body, symptom *(signum)*, and cause. . . .

Moreover, the efficient cause is primitive, or antecedent, or conjoined *(conjuncta)*. An example of the "primitive" cause is air and foods; of the "antecedent" cause is the humors; and of the "conjoined" is the putrefaction of the humors (that is, body fluids), which is continually followed by fever. Among the natural sciences, therefore, medicine excels in the nobility of its matter, the human body, because the latter excels all natural bodies.

This science is sometimes had by the cognition of the mind alone and sometimes by the exercising of the body. Therefore, according as it is a science of recognizing the principles and precepts of an art, it is theoretical, just as when we say that there are three kinds of fever and nine species of complexions. But insofar as it is a science of operation, it is practical, just as when we say that at the

39. An elaborate program of inquiry of this kind precedes each of the sciences in this treatise; (for example, see the last paragraph of the Prologue.)

beginning there ought to be applied to hot abscesses things that would repel, cool, and thicken; and afterwards we will temporize the repellents with resolvements. . . .[40]

The parts of theoretical medicine are two: the science of conserving health and the science of curing infirmity. These two sciences coming together produce the perfect physician. . . . The parts in truth of practical medicine are three: pharmacy, surgery, and diet.

Pharmatica in Greek is translated in Latin as *medicamentum* (a medicant); *cirurgia* is translated *manus operacio* (manual operation); *dieta* is translated *regula* (rule or reigmen). Pharmacy is therefore a cure by medicants; surgery is incision with instruments; diet is the observation of a law and a way of life. Every cure of disease takes place in these three ways.

The species of this art are the three dispositions of the body: health, sickness, or neutrality. . . . The function of the art is twofold: to conserve by regulation healthy bodies in their state of health and to recall sick or neutral bodies to health. . . . The end [or goal] is twofold: the conservation of health by regimen or the recovery of health through a cure, that is, the expulsion of sickness or neutrality. . . .

Since the instrument is that through which the artificer fulfills his function, therefore diet is the instrument for regulating health. Species of herbs, potions, unguents, and similar things are instruments for the curing of sickness and neutrality. For this reason there are two kinds of those instruments: some are natural and some are artificial. The natural instruments are simple things like herbs, species of fruit, stones, and metals. The artificial instruments are composite, as camphors, potions, unguents, plasters, clysters, pisaria, and surgical instruments.

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Why is medicine so called? "Medicine is derived from *modus,* that is, from "moderation," that is, from a due proportion which advises that things not be done immediately *(statim),* but "little by little" *(paulatim).* For nature is pained by surfeit but rejoices in moderation. Whence also those who take drugs and antidotes constantly, or to the point of saturation, are sorely vexed, for every immoderation brings not health but danger."[41] Therefore, medicine is derived from *modus* (mean) in that the *modus* and *mensura* (measure) in all bodies subjected to medicine are conserved by it; or it is called medicine *(medicina)* from "mean" *(mediocritas).* For medicine ought to do this: either to conserve the mean state *(mediocritas),* that is, the health, or to repair a fault in some body. Those bodies in which we see elements joined together with equal measure we judge to be temperate. We conserve these bodies in their state by using "similar things" having the same measure of elements. But in distemperate bodies we see the mode and measure of a distemperate body [that is, the measure is off the mean], so that we should cure them by using "contraries" which are distemperate in the same degree.

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Since it is in need of all the other arts, it certainly ought to be read after all of them,[42] so that the cognition of those sciences without which it itself is not efficacious would come first.[43]

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ON ARITHMETIC

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. . . .Arithmetic is defined thus: "Arithmetic is the science of quantity numerable according to itself."[44] Or, "Arithmetic is the science of number." Number, moreover, is considered in two ways: (1) as it is in sensibles and non-sensibles, and (2) as it is considered more abstractly through the intellect apart from everything in which it exists.[45] In sensibles it is like "three" in "three men"; in non-sensibles it is like ["three"] in "three angels." It is considered abstracted from everything through the intellect when we say, "Three is the first odd number [that is, the first number] which cannot be divided into two equal parts." Therefore, in both sensibles and insensibles it is considered when it is numbering [something] or is numbered. But it is

40. Drawn from Avicenna's *Canon of Medicine,* I, fen 1, doct. 1.

41. This is a direct quotation from Isidore of Seville, *Etymologies,* Book IV, chapter 2. The translation of this passage given in Selection 89 has been altered slightly to accommodate the minor differences in Gundisalvo's text.

42. In a preceding paragraph taken almost verbatim from Isidore's *Etymologies,* Book IV, chapter 13, but omitted here, Gundisalvo shows how a physician must have knowledge of grammar, rhetoric, dialectic, arithmetic, geometry, music, and astronomy.

43. Gundisalvo concludes his section on medicine with another unacknowledged quote, taking all of Isidore's *Etymologies,* Book IV, chapters 3 and 4 (these have been translated in Selection 79).

44. Quoted from Isidore's *Etymologies,* Book II, chapter 24, paragraph 15.

45. This twofold division appears based on al-Fārābī's discussion in the third chapter of *De scientiis* (Palencia, p. 145).

abstract when it is neither numbering nor numbered. Number therefore considers those things which are considered in both ways, in itself, or in matter with motion or without motion. . . .Whence according to this (reasoning) some things happen to number from itself; others from its being mixed with matter. The things that happen to it from itself are (for example) that it is odd or even, in excess or diminished, and other things of this kind —things which are pointed out in the Arithmetic of Nichomachus.[46] That which happens to it out of matter is, for example, its being added, subtracted, multiplied, divided, and things of this kind—things which are taught in the *Book of Algorism.*[47] When number is directed to itself, it is called "theoretical" or "speculative." But when it is considered in matter, it is called "practical" or "active." And through this (definition) theoretical arithmetic asserts that no number has been composed out of numbers but only out of units. Nor does it concede that any number is the part or parts of another, because it regards any number at all as a species in itself in that the specific difference, such as "threeness," embraced by the genus which is "number," constitutes this species which is "three." It can be reasoned in the same way concerning other numbers. And therefore [number] divides no number, unless into units only—but not into numbers. Practical arithmetic only considers number in matter which is divisible in many ways. Hence it divides one number into parts and the parts into parts into infinity. It calls its parts fractions, and the parts of parts, fractions of fractions. . . .

The genus of arithmetic is the first of all mathematical disciplines, which considers what is unabstracted and without motion.

The matter of arithmetic is number, since it treats of the accidents of numbers. Although arithmetic is called the science of number, it does not, however, treat of the essence of number, for no science establishes its own subject matter, as Aristotle says.[48] But it does assign properties to number, and it treats those things which happen to number either of itself or from its mixture with matter. It is for another science to treat of the essence of number, namely the divine science (metaphysics) on which it is incumbent to prove the (first) principles of all the sciences.

Moreover, there are some theoretical, some practical, parts of arithmetic. The theoretical parts are three: The first is a consideration of those things which happen to number by virtue of its own essence, such as the fact that some number is even, some odd, and similar things. The second part is consideration of those things which happen to it out of the proportioning of one number to another, such as the fact that some number is a multiple [of another], and another is superparticular to another,[49] and so on. The third is a consideration of what happens to it from a comparison of it to continuous quantities—for example, a certain number is lineal, another two-dimensional (superficial), a third is a cube, still another a solid (that is, any other three-dimensional figure which would be represented by a number), and similar things.

The practical parts are in the main two: the science of conjoining numbers and the science of disjoining numbers. The science of conjoining numbers is the science of adding, the science of duplication, the science of multiplying, [and so on]. The science of disjoining consists of the sciences of subtracting and dividing. However, the science of finding roots of numbers is contained under each of these two, since the root of a number is found in both ways, that is, by multiplying and dividing.

The species of arithmetic also consists of theoretical and practical parts. The species of theory are three: The first is called the arithmetical mean, the second the geometrical mean, and the third the harmonic mean. All of these things are treated in the Arithmetic of Nichomachus.[50] The species of practical arithmetic are in truth the various kinds of businesses in each of which the whole art is employed. . . .All these things (concerning practical species) are treated in the book which is called in Arabic *"Mahamelech."*

The function *(officium)* of theoretical arithmetic is to investigate diligently the natures of numbers. . . .Its end [or goal] is the cognition of all things by the example of numbers. The function of practical arithmetic is fully to conjoin and disjoin numbers of every species [or kind]—integers and fractions. Its end [or goal] is to prevent errors of numbering in every kind of business. The instru-

46. Compare Boethius, *On Arithmetic,* Book I, chapter 2 (Selection 2).

47. Books on algorism considered arithmetic operations; see Selection 20, from Sacrobosco's *Algorism.*

48. Compare *Posterior Analytics* I.1.71a.1–10.

49. For the meaning of superparticular see Selection 1, "On the Quadrivium," chapter 6, paragraph 7, and note 17.

50. For Nicomachus' account of these three "species" as it appears in the paraphrase of Boethius, see Selection 2, chapters 43–45.

ment of theoretical arithmetic in truth is demonstration. . . .While the instrument of practical arithmetic is the table of the abacus *(tabula abachi)*, or the *rithmamachia*, which is the game of contesting numbers according to their proportions *(ludus de pugna numerorum secundum proportiones eorum)*. The artificer is the arithmetician. . . . Arithmetic, moreover, is spoken of as the science of the "virtue" (power) of number, for *"ares"* is translated *virtus*. . . .[51] The "order" of arithmetic is this, that it is prior to all the disciplinal sciences because it is lacking in none of them. . . .[52]

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ON GEOMETRY

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. . . .Certain people have defined geometry thus: "Geometry is the discipline of magnitude and forms which are considered according to magnitude." Others, however, define it in this way: "Geometry is the science of rational magnitudes investigated by reason of probable dimension." It speaks of "rationals" in contradistinction to "irrationals," that is, surds, whose dimensions are not probable; an example of the latter is the quadrature of a circle.

Its genus is that it is one of the four mathematical disciplines, inquiring into things abstracted and with motion, for every discipline of theoretical philosophy either is abstracted or unabstracted, either with motion or without motion. . . .

Its matter *(materia)* is immobile magnitude: line, surface, and solid. It is therefore called "immobile magnitude," since they (that is, line, surface, and so on) are understood as abstracted from matter without motion. Indeed, they are moved in matter, which is always in motion because, as Boethius says, they are changed by contact with a variable thing. Therefore, these things are considered in two ways, as they are outside of matter and inside of matter. Insofar as they are in matter, they are sensible but are not sensed [or perceived] except as they are mixed with other things without which they cannot exist in matter. For they are sensed [or perceived] with visible colors, or with sounds that are heard, or with the smell of an odor or foul smell, or with sweet or bitter taste, or with touch [they are perceived as] hot or cold. But when they are outside matter, they are understood as separated from the things with which they are conjoined in matter.

But since geometry need consider these things in both ways, therefore some of geometry is practical and some theoretical. Practical geometry accepts these things as they are mixed in matter with other things [as color, sound, and so on,] although it has no regard for these other things with which they are mixed. . . .Theoretical geometry, however, abstracts things from matter by the intellect, and it not only distinguishes them from the things with which they are mixed, but even indeed from themselves, that is, one from the other. It considers these things individually abstracted per se and demonstrates any one of them by itself by defining what it is.

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Now theoretical [geometry] has parts, and practical geometry has parts.[53] There are three theoretical parts: one considers lines, another surfaces, and another bodies. The part concerned with bodies is divided into the number of [types of] bodies, namely into cubes, pyramids, spheres, cylinders, . . .Speculation considers all these in two ways: in one way when it considers any one of them by itself; and in the other way when it compares any one of them in terms of the things which happen to them. Moreover, when it compares them to one another, it considers either their equality or inequality, or some other of their accidents; or it considers how one can be arranged on another—namely how a line can be [placed] on a surface and a surface on a body, or a surface on a surface and a body on a body.

The distinction between natural body and mathematical body ought to be noted. "Natural body" is substance in which can be placed three lines cutting each other at right angles; and thus it is in the category of substance. "Disciplinal (mathematical) body" is extension in three directions: length, breadth, and thickness. . . .and thus it is in the category of quantity.

. . . . .

The species of geometry also has a theoretical part and a practical part. The species of theoretical geometry are three: operation [or action], knowledge, and discovery. Anything at all which is proposed in this art is in truth proposed for acting, knowing, or finding out. For "acting" there are proposed, for example, the first and second the-

51. Compare Hugh of St. Victor above, Selection 16, n. 12.

52. An elaboration of this point concludes the section on arithmetic, which is followed by a lengthy section on music that is omitted here.

53. The section containing the practical parts is missing from the edition.

orems of Euclid and many others, which are proposed here in order that we might "do" them. For example, it is proposed that we construct an equilateral triangle upon a given straight line and from a given point we draw another line equal to a proposed straight line.[54] At the end of these and similar [propositions for action] it always ought to be said, "and this is what we wished to do." For "knowing," however, propositions like the fifth theorem of Euclid and similar ones are proposed. This fifth theorem is this: If the two angles above the base of any triangle are equal, then the angles which are below the base will be equal. At the end of this and similar propositions it ought to be said, "and this is what we wished to know." For "finding out" are proposed such things as the first theorem of the third book and many others; for example: To find the center with the circle given, for although we know that every circle has a center, we do not know where it is. At the end of this and similar propositions we ought to say, "and this is what we wished to find. . . ."

The end [or goal] of theoretical geometry is to teach something; while the end of practical geometry is to do something. . . .

The species [or types] of practical geometry are also three: altimetry, planimetry, and cosmimetry, [that is, height measurement, surface measurement, and the measurement of solids]. . . .[55]

. . . .The artificer of theoretical geometry in truth is the geometer who has become acquainted thoroughly with all parts of geometry and teaches it. Its instrument is demonstration. The parts of this demonstration are assigned in different ways. According to Boethius they are six: the proposition, the description, the disposition, the distribution, the demonstration, and the conclusion. According to the Arabs, however, there are seven: the proposition, the example, the contrary, the disposition, the difference, the reason, and conclusion.[56] The descriptions of all these [parts of a proposition] are assigned to those who begin to read the book [of *Elements*] of Euclid.

The artificer of practical geometry is he who employs it in working. There are, however, two classes who employ it in working, the measurers and the artisans. The "measurers" are those who measure the height, the depth, or the level surface of the Earth. The "artisans" are those who exert themselves in manufacturing or in working in the mechanical arts, as a carpenter works on wood, an iron worker on iron, a stone mason on cement and stones, and similarly every artificer of the mechanical arts works according to practical [or applied] geometry. For he forms lines, sufaces, squares, roundnesses, and so on, in the body of the matter which is subject to his art. Now many species, [or types] of these skills are considered by the difference of materials on which and from which they work. Any one of them has its appropriate matter and instruments. For measuring there are the foot *(pes)*, palm *(palmus)*, cubit *(cubitus)*, stade *(stadium)*, pole *(pertica)*, and many others. Of instruments, the carpenters use the hatchet *(securis)*, and ax *(ascia)*, pickax and line, and many others; the iron worker uses the anvil *(incus)*, shears *(forfices)*, hammer, and many others; the stone mason uses line, trowel, and perpendicular, and many others.

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Why is geometry so named? This discipline receives its name from measure of the earth, for *ge* is translated "earth" and *metron*, "measure" . . . .[57]

. . . . . .

Geometry ought to be read after music. This is reasoned as follows: There are two species of quantity, obviously multitude and magnitude. Moreover, there are two species of multitude: number per se [or absolute number], of which arithmetic treats, and related number, of which music treats. After multitude, magnitude necessarily follows, of which one part of it is immobile, and geometry treats of this, and the other part mobile, astrology treating of it. Moreover, the immobile is before the mobile, since every motion begins from rest. This shows that in the order of the four mathematical disciplines [or sciences], the third, after arithmetic and music, naturally treats geometry. [Hence] by this argument geometry ought to be read after music and before astrology.

. . . . . .

54. These are the enunciations of the first two construction theorems of the first book of Euclid's *Elements*.

55. The same threefold division of applied geometry is found in Book II, chapter 13, of Hugh of St. Victor's *Didascalicon* (see Selection 16).

56. Proclus, in his commentary on Book I of Euclid's *Elements*, divided a proposition into six formal parts (see Thomas Heath, *The Thirteen Books of Euclid's Elements*, 2d. ed [New York: Dover, 1956], I, 129–131).

57. The remainder of this paragraph concerning the invention and application of geometry in Egypt is based upon Isidore of Seville's *Etymologies*, Book III, chapter 10, quoted in Selection 1.

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ON ASPECTS [OPTICS][58]

The science of aspects [or optics] inquires about the same things as does geometry, namely figures, magnitudes, positions, order, equality, inequality, and other things, except that [in optics] these entities are in lines, surfaces, and bodies absolutely, so that the science *(speculatio)* of geometry is more common [or universal] than this science [of optics]. But although what it treats is contained in that of which it treats, this is not superfluous but necessary, since what Euclid has proved to be a square necessarily appears to be round when seen from a certain distance; and many things which are equidistant seem to run together, and equals seem to be unequals and conversely. Of things situated in one plane, some appear lower and others higher; and of those things that are before [or in front of] others, some appear behind; and conversely. For this reason, this science was necessary so that it could distinguish between what appears to the sight otherwise than it is and what appears just as it is. Indeed, this science assigns the causes of these things and does this by necessary demonstrations. It also teaches how vision can err so that it might not err but [rather] discover just how everything is that it sees. It also teaches how to detect [or determine] the heights of trees, towers, walls; the widths and depths of rivers and the heights of mountains after the sight falls upon their limits [or boundaries] *(fines)*; then the elongations of celestial bodies and their quantities and everything which can be reached from reflection by the one who sees it; and some of these require an instrument, others do not.

And it teaches that anything seen is seen only by means of a ray penetrating the air and falling continually on the thing at which we are looking. And the rays penetrate transparent [or pervious] bodies until they reach what is seen and then are direct [that is, straight], reflected, reversed, or refracted. Rays are straight when after emerging from the eye *(viso)*,[59] they are extended in a straight line until they traverse their distance and terminate. Rays are reflected when they begin to emerge from the eye and a mirror obstructs them before they traverse [some distance]; they are reflected from the mirror obliquely toward parts on the sides of the mirror and then they are extended to the sides and go on to the body to which they are reflected. The one who is viewing holds the mirror between his hands in this way:

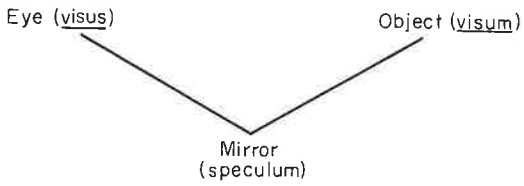

Fig. a

Rays that are reversed *(conversi)* are those which follow the same path returning from the mirror as they followed in previously advancing [toward the mirror]. They return until they fall on the body of the one who is seeing [or looking]. It is for this reason that a man looking at a mirror sees himself with the very same ray. Refracted rays, however, are those which, in returning from the mirror to the side where the viewer is, are extended crookedly from the mirror to one of the viewer's sides and fall on something behind the viewer or to his right or left or above him. For this reason, a man sees what is behind him or what is on one of his sides, as this figure shows:

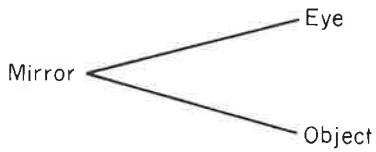

Fig. b

The medium which lies between the eye and what is seen without a mirror consists entirely of transparent bodies as water or air, or celestial bodies or crystalline bodies. Therefore, the science of aspects [or optics] investigates everything that is seen and everything that is viewed with these four rays in any mirror; it investigates everything that happens to the object to which the rays are directed. Whence it is divided into two parts, of which the first is an inquiry about what is seen with straight rays;[60] the

58. With slight variations and alterations, Gundisalvo adopted the whole of al-Fārābī's section *On Aspects*, probably because this subject was wholly new to him since it had not been considered as part of the earlier Latin tradition on the classification of the sciences (it is absent from Hugh's *Didascalicon*).

59. Gundisalvo has adopted the traditional view that visual rays move from the eye to the object perceived. See Selections 62. 14–17.

60. Baur's text is faulty here. Instead of *cum rectis radiis* (with straight rays), as al-Fārābī has it, Baur has *cum istis radiis*.

second investigates what is seen with non-straight rays. And this is properly called the science of mirrors *(scientia de speculis)*.

ON ASTROLOGY

. . . . . .

. . . Astrology is defined as follows: "Astrology is the science of mobile magnitude which seeks out with searching reason the courses of the stars, their figures, and the relations *(habitudines)* of the stars both with respect to themselves and with respect to the Earth."

Its genus, that is, its quality, is that it is mathematical, a doctrinal science. Its matter (material object) is mobile magnitude. Moreover, we call magnitudes mobile which are moved, for example the sun, the moon, and the other planets, the movement of which astrology treats. . . . The matter of astrology is spoken of as "mobile magnitude" not because it considers the magnitude of moving bodies but because it would investigate the motion of the great moving bodies, as for example the seven planets and the ten heavens.

There are three parts to this art.[61] The first is concerned with the numbers and figures of celestial bodies, their order in the world, their mutual quantities, locations, and proportions, and with the quantities of their mutual elongations. And it holds that the whole earth is not in local motion—neither in a place nor from a place. The second part treats of the motions of the celestial bodies—how many there are, that all their motions are spherical [that is, circular], and which of these motions could be communicated to all the celestial bodies, that is, the stars and non-stars—and what is common to all the stars. Next comes [an inquiry into] the motions proper to each star, how many kinds of motions there are for any one of them, and the parts [or directions] to which the stars are moved and in what direction does this motion come to any one of them. It also teaches the way to understand the position of each star in terms of the signs [of the zodiac] in any hour and with all its types of motion. It inquires about all things that happen to celestial bodies and the motions of each of them in the signs [of the zodiac] and what happens to these when they are mutually compared with respect to conjunction, separation, and difference of position. And finally, [astrology inquires about] everything that happens to these bodies from their [own] motions without relating them to the earth, as an eclipse of the sun; but again [it also inquires about] everything that happens to them because of the position of the earth with respect to them, as an eclipse of the moon. And it states their accidents—how many there are, in what disposition and hour they occur, and in how much time, as [for example] the risings and settings, and other things. The third part inquires about the earth—what is inhabited and what uninhabited; and it shows how much is inhabited and how many great parts [or divisions] of it there are, and what the climes are. It embraces the habitations that exist in any of these climes in that time and where the location is of each habitation and their arrangement in the world. It inquires about what follows necessarily from the revolution of the world that would happen to any of these inhabited climes: there is the revolution of day and night because of the position of the earth in its place [and] on which there are risings and settings, length of day and night, and brevity [of day and night], and other things similar to these. These, therefore, are the parts of astrology.

Its species are two: active and contemplative. Contemplative astrology is the science of all the aforementioned parts. The practical is the science of comprehending through competent instruments the magnitudes, elongations, and mutual comparisons of the celestial bodies.

The function *(officium)* of this art is to assign, by use of the most certain reasons, the magnitudes, differences and proportions of the celestial bodies and the Earth. Its end [or goal] is the sure cognition of those things which are of the visible, incorruptible universe—of those bodies which do have existence neither through generation nor corruption—bodies which are neither [pure] elements *(elementa)* nor [visible] elements *(elementata)* nor natural things nor artificial. For there are three worlds or parts of the world: (1) The first of these is the visible and corruptible one which extends from the center of the Earth up to the circle of the moon. Natural science treats of this world. (2) The second is the visible and incorruptible world, which extends from the moon up to the last heaven. Astrology treats of this one. (3) The third is the

61. These three parts are very nearly a direct quotation from al-Fārābī's discussion of the "Science of the Stars" in chapter 3 of *De scientiis*. It will be noted that al-Fārābī and Gundisalvo reverse our usual understanding of the difference between astronomy and astrology (see Gundisalvo's next section on astronomy), whereas Hugh of St. Victor (Selection 16, chapter 10) retains it. Perhaps this results from the fact that the terms were often used interchangeably.

invisible and incorruptible world, which is neither outside of the heavens nor within them. Theology treats of this last world. Hence, the goal of astrology relates to the cognition of the world of the fifth essence. For the first world is called the "world of nature," the second is called the "world of the fifth essence," and the third is called the "world of intelligence."

The instruments of astrology are the many which Ptolemy teaches how to make in the *Almagest*. . .

Why is astrology so called? Astrology is called the science of the reason of the stars, for *logos* is translated "reason" *(ratio)*. Hence this art is called astrology—the science of the reason of the stars—because whatever it says of the stars, it proves by rational procedures. It ought to be read after geometry but not continually. Nay, the books of certain authors ought to be interposed—introductory books which when known first will lead one easily to the cognition of astrology. The first is Mileus, the second Theodosius, and the third Ascalonita. There then remains to be read after these authors the *Book of the Almagest* in which all of astrology is most fully taught.[62]

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ON ASTRONOMY

There is another science of the stars which is called "astronomy. . . ." What it is, is defined in this way: "Astronomy is the science which describes, according to the belief of men, the courses and position of the stars, for obtaining a knowledge of the times."

Its genus is that it is a science for judging a question deemed necessary according to the position of the planets and signs. For there are many sciences of judging a proposed question, for example, geomancy, which is divination in earth; hydromancy, divination in water; aeromancy, in the air; pyromancy, in fire; chyromancy in the hand, and many others. . . .Thus al-Fārābī says that astronomy is a science of the signification of the stars, namely what the stars signify about the future and many things in the present and the past. Nor are these [sciences of judgment] among the disciplinal [that is, mathematical] sciences but among the forces and powers *(virtutes et potentias)* by which a man can judge of future events just as the power of interpreting visions and the power of auguring in birds and sneezes and other such ways.

Its matter (material object) is mobile magnitude. Its "parts" are four, the first of which treats of the position and form of the Universe and of the celestial circles. The second treats of the course of the planets and their circles. The third treats of the rising and setting of the signs. The fourth treats of the eclipse of the sun and the moon, and all of astronomy is absorbed into these four parts. The species of astronomy are two: computation and judgment. Computation is constituted in tables, judgment in the distinction of the seasons, the signs, and the planets.

The function of this art is to contemplate the mutual courses, conjunctions, retrogradations and retreats of the planets. The end [or goal] of it is a science for judging about the past, present, and future.

. . . . .

. . .Astronomy differs from astrology in that the latter relates to the "truth" of the matter: while the former follows the opinion of men. According to Isidore, they differ in this, that astrology embraces the revolutions of the heavens, the rising, setting, and motion of the stars, or from what source (cause) they would be so moved. Astronomy in truth is partly natural, partly superstitious. It is natural while it plots the courses of the sun and the moon or the fixed positions or the times of the stars. The superstitious part is that which is followed by the "mathematicians," who make conjuries by means of the stars and who also arrange the twelve signs by singularities of the soul or members of the body, and who attempt to prejudge the manners and nativities of men by means of the course of the stars.

ON THE SCIENCE OF WEIGHTS (SCIENCIA DE PONDERIBUS)[63]

The science of weights considers weights in two ways: either (1) according to the weights themselves that are being measured or according to what is measured with them and by them; and this is an inquiry about the principles of the doctrine on weights. Or (2) it considers them in so far as they are moved or according to the things with which they are moved; and this is an inquiry about the principles of instruments by means of which heavy

62. Gundisalvo concludes his discourse on astrology by quoting almost the whole of Isidore's *Etymologies*, Book III, chapter 25 (Selection 1).

63. This is virtually a quotation of the whole of al-Fārābī's brief section on the science of weights (Palencia, p. 154).