NICHOLAS OF CUSA
ON
WISDOM AND KNOWLEDGE

BY JASPER HOPKINS

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To the memory of my brother

William Eugene Hopkins
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Ph.D. in Philosophy
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IDIOTA DE STATICIS EXPERIMENTIS

(The Layman on Experiments Done with Weight-scales)

by

NICHOLAS OF CUSA

(Codex Cusanus Latinus 218, ff. 132^{r} - 137^{v})

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THE LAYMAN ON EXPERIMENTS DONE WITH WEIGHT-SCALES[1]

The Roman Orator[2] used to visit often with the Layman in order on occasion to learn of his ideas—ideas which the Orator found pleasing. And when the Orator praised weight-scales[3] as scales of justice and as necessary instruments of the State, the Layman replied: "Although in this world nothing can attain unto preciseness, nevertheless we know from experience that the verdicts of weight-scales are quite accurate and that, therefore, they are generally accepted. But since with regard to objects that have different origins it is not possible for equal weights to be present in identically sized objects, please tell me whether or not anyone has [ever] written down the different experimental results pertaining to weights."

Orator: I've neither read nor heard of [any such thing].

Layman: O that just anyone would present us with this writing! I would value it above many [other] written works.

Orator: If you had a mind to do so, I think that [such a work] could be produced by no one better [than by you].

Layman: Any willing individual could do so, since doing so is easy. But I lack the available time.

162 *Orator:* State the usefulness and the manner [of doing so]. I'll see whether I or someone else can do it.

Layman: It seems to me that by reference to differences of weight we can more truly attain unto the hidden aspects of things and can know many things by means of more plausible surmises.[4]

Orator: Your point is well-taken. For a certain prophet said that weight and weight-scales are the judgment of the Lord, who created all things in number, weight, and measure and who balanced the fountains of waters and weighed the foundation of the earth, as [Solomon]-the-wise writes.[5]

Layman: So if the amount of water from one source is not of the same weight as is a similar amount [of water] from another source, then a judgment about the difference-of-nature between the one source and the other source is better arrived at by means of a weight-scale than by means of some other instrument.

Orator: Well said. Vitruvius,[6] writing on architecture, cautions that we are to choose as a place of residence a location that has lighter and more sky-blue waters and we are to avoid a location that has

heavy and earthened-colored waters.

163 *Layman:* Therefore, just as waters from the same source seem to be of the same weight and nature, so too [waters] from different [sources seem to be] of different weights.

Orator: You say "seem to be"—as if, in fact, something else were the case.

Layman: I am acknowledging the fact that weights vary according to the circumstances, although at times [they do so] imperceptibly. For without doubt the weight of water is one thing at one time and another thing at another time. Likewise, the weight of water at its source is one thing, whereas its weight at a distance from its source is another thing. But oftentimes these scarcely perceptible differences are considered to be of no account.

Orator: Do you think that in *all* cases the situation is as you indicated it to be in the case of water?

Layman: Yes, I do. For identical sizes, of whatsoever different things, are not at all of the same weight. Accordingly, since the weight of blood or the weight of urine is different for a healthy man and for a sick man or for a youthful man and an elderly man or for a German and an African, wouldn't it be especially useful to a physician to have all these differences recorded?

Orator: Most certainly. Indeed, through the recorded weights, the physician could render himself admirable.

Layman: I think that a physician can make a truer judgment from the weight of urine together with its color than from just its color,[7] which is misleading.

Orator: Most certainly.

164 *Layman:* So too, since the roots of herbs and their stems, leaves, fruit, seeds, and sap have their own respective weight: if the weights of all herbs were recorded along with the variety of the herbs' locations, then a physician would better attain unto the nature of all the herbs by means of both their weight and taste than by means [only] of their taste, which is misleading.

Orator: Very well put.

Layman: Then from a comparison of the weights of the herbs with the weight of the [man's] blood or urine the physician would know—on the basis of the agreement or the difference [of weights]—how to arrive at the [correct] deliverable dosage of the drug. And he would know how to make impressively correct prognoses. And, thus,

by means of experiments done with weight-scales he would draw nearer, through a more precise surmise, unto all that is knowable.

Orator: It is quite amazing that up until now so many diligent investigators have been inactive with regard to the recording of weights.

Layman: If you were to allow water to flow through the narrow aperture of a water-clock into a basin during the time that you counted the pulse-beat of a healthy adolescent one hundred times, and if you did a similar thing with respect to a sick adolescent, don't you think that there would be a difference of weight between those [two collections of] water?

Orator: Who doubts it?

165 *Layman:* Therefore, by reference to the weight of the [collections of] water we could ascertain a difference of pulses in the case of someone young, someone elderly, someone healthy, and someone sick. And, likewise, we could arrive at a truer knowledge of the illness; for, of necessity, there would be one weight with respect to one illness and another weight with respect to another illness. Hence, from a consideration of such different experimental results pertaining to the pulses, together with a consideration of the weight of urine, a more accurate judgment could be made than [could be made] merely from feeling the pulse and [assessing] the color of the urine.

Orator: Excellently stated.

Layman: Moreover, if by means of the aforesaid relation between the respective weights of water [a physician] were to attain unto the breathing,[8] in terms of inspiration and expiration, wouldn't he make a still more precise judgment [about someone's physical condition]?

Orator: He certainly would.

166 *Layman:* For example, if while the water were flowing from the water-clock he were to count one hundred expirations in a boy and likewise in an elderly man, it is not possible that the waters would turn out to be of the same weight. A similar thing holds true, I say, with regard to other different ages and different physical conditions. Hence, if there were evident to a physician the weight [of water that flowed] during the expiration period of a healthy boy or a healthy adolescent, and likewise of [a boy or an adolescent] sick with some malady or other, surely by such an experimental procedure the physician would arrive more assuredly at a knowledge of health, at a knowledge of the falling off of health, and at a [correct] dosage of remedying medica-

tions.

Orator: Indeed, [he would] also [arrive more assuredly] at [better] surmises about the course [of the disease].

Layman: You are right. For example, if [the physician] were to find in the case of an [ostensibly] healthy adolescent the weight [of water] characteristic of an elderly and decrepit man, he would surmise that the adolescent would fairly soon be going to die; and he would make [other] such impressive surmises. Furthermore, if in a similar way as regards those with fevers, he were to note down—in terms of a difference in the weights of water—the sudden episodes of feeling hot and of feeling cold, couldn't he arrive more truly at [an estimate of] the virulence of the disease and at [an estimate of] the timeliness of the remedying medication?

Orator: Undoubtedly, he could! For he would ascertain by experience the triumph of the one quality over the other—of the heat over the cold, or vice versa. And according to the ascertained relation he would apply the remedies.

167 *Layman:* Moreover, I claim that where the ages [of the patients] are equal these findings would [nonetheless] vary with the various nations, regions, and times. Hence, it would be very useful (although difficult) for the variety of weights to be described in all respects.

Orator: The matter is just as you state it to be.

Layman: Now, it seems that the respective weight of each thing would have to be considered as the mean of its different weights at different latitudes. For example, if the weight of a man in comparison to [the weight of] some other animal were to be considered, then the man would have to be considered not as a northerner or as a southerner (where in both directions there is an extreme) but rather as an inhabitant of an in-between latitude.

Orator: Excellently stated. The ancients called that [middle] latitude *Diarhodos*, for it stretches from east to west, passing *through* the island of *Rhodes*. But if, pray tell, you were seeking to determine the weight of a whole man in comparison with [that of] some other animal, how would you proceed?

Layman: I would place the man on a balance-scale, to which I would add a similar weight on the other side. Then I would put the man into water, and once again I would add an equal [weight] on the other side, outside the water; and I would note the difference in the weights. I would do likewise with the given animal. And from the various differences of the weights I would take note of what was being

sought. Thereafter, I would pay attention to the difference between the man's weight and the animal's weight [when the man and the animal were] outside the water. And in accordance therewith I would adjust what I found out and would write it down.

168 *Orator:* I don't understand this [notion of] adjusting.

"I will show you," said [the Layman]. And taking a piece of light wood, whose weight was, say, three pounds, and the weight of water of the same magnitude being, say, five pounds, he divided the wood into two unequal parts, one of which had twice the size of the other. He placed both parts into a deep cask and held them down with a stick and poured the water over them. And when he withdrew the stick, the pieces of wood rose to the surface of the water, and the larger piece rose more quickly than did the smaller piece. "Look!" he said. "You see that the difference of motion occurs, in a sameness of proportion, from the fact that in the [two] pieces of light wood greater lightness is present in the larger piece."

Orator: I see and am greatly pleased.

Layman: In a like way, I say that an adjusting must be made. For if because of his size a man were to have more heaviness than an animal, then in water he would sink more quickly than would an animal of the same proportion.[9] Therefore, it would then be necessary that an adjusting of the ascertained difference be made by making a proportional reduction in accordance with the discrepant size.

169 *Orator:* Now I understand. But tell me how it is that the water resists the wood's sinking.

Layman: [It resists] as the more heavy [resists] the less heavy. Therefore, suppose you press a piece of round wood [all the way] into a piece of wax, remove the wood, fill the depression with water, and note the weight of both the water and the wood. You will find (1) that if the weight of the wood exceeds the weight of the water, the wood will sink but (2) that if [the weight of the wood does] not [thus exceed], the wood will float and a part of the wood will remain above the water in proportion to the greater weight of the water over the weight of the wood.

Orator: Why do you specify a piece of *round* wood?

Layman: If [the piece of wood] is of a wide shape, it will displace more of the water and will float higher up [in the water]. This is the reason that ships in shallow waters ought to have a fairly wide bottom.

170 *Orator:* Continue with what was begun. [Tell me] whether the

weights of animals can be assessed in some other way.

Layman: I think they can. For example, suppose that you filled a tub up to the top with water and placed it into another tub. [And suppose that] then you measured the weight of a man outside the water and subsequently made him submerge himself in that tub. [And suppose] you collected and weighed the water that overflowed. [And suppose] you proceeded in a similar way with the other object (whether a man or an animal or whatever other thing). From the difference of weights, you would obtain, by a careful calculation, the answer being sought.[10]

"I have heard," said the Orator, "that sometimes by means of this technique the difference between metals is very subtly detected and that some men have taken note of how much gold, silver, copper (and so on regarding all other metals) the casting-mold for an ounce of wax collects.

171 *Layman:* He who understood magnitude in terms of casting is worthy of praise. For he recognized that if gold were to occupy as much space as does an ounce of wax, the weight of the gold would be such and such—and similarly regarding other metals. For it is altogether certain that the weight of gold and the weight of an equal portion of silver (and of other things) are different and that each thing's weight in air is different from its weight in water, in oil, or in some other fluid. Hence, if someone were to keep records of all those weights, he would surely know how much heavier one metal is than another [when they are] in air, and how much heavier in water. Accordingly, if he were presented with a certain [metallic] mass, then by reference to the difference of its respective weight in air and in water he would be able to know out of what metal it was composed or out of what mixture [of metals]. And just as is stated regarding air and water, so too it could be stated regarding oil or any other liquid with respect to which the experiment could have been made.

Orator: In this way the mixture could be assessed without any melting of the [metallic] mass or any separation of the metals. And in the case of money this technique would be useful for determining how much copper was admixted with the gold or the silver.

Layman: You're right. [The technique] would also avail very much for knowing how greatly the adultered products of alchemy veered from the real thing.

172 *Orator:* So if someone were to undertake to write down a book

of weights, then, as it seems, he would also have to note down the variation of each metal. For example, Hungarian gold is of one weight, and pure gold[11] is of another weight, and so on for every other metal.

Layman: From the aforesaid it is evident that just as with the springs [of water] so also with minerals there can be found a difference of weights. Nevertheless, wherever gold is found it is always heavier than any other metal. Hence, the species of gold is found to vary within a certain range of weights. A similar thing holds true regarding other [metals].

Orator: Can the relation between the natures of the metals be detected from the relation between the weights of the metals?

Layman: Lead is quite similar in weight to gold but is not at all similar in perfection. Hence, I think that we must pay attention not just to one [kind of] weight but to every [kind of] weight. For example, if someone pays attention to the weights of the fire[12] that melts gold and of the fire that melts lead, he finds that lead comes less near to gold than does some other metal. And if someone pays attention to the weights of fire with regard to melting iron, he realizes that iron comes closer to gold than does any other metal—even though with respect to weight, in terms of heaviness, [iron comes] less [close to gold]. Hence, all [kinds of] weights—not just heavy weights—should be taken notice of, and then we will find that silver comes quite close to gold.

173 *Orator:* Vitruvius said concerning the weight of gold's nature that only gold (no matter of what little weight it is) sinks in mercury, whereas other metals (no matter of what large size they are) float.

Layman: Mercury is combinable with all metals because of what is common to it and to them. However, mercury adheres more closely to gold, just as the imperfect adheres to its own very perfect nature. Hence, those who are engaged in alchemy seek to temper mercury in fire to the point at which it not only does not evade the fire but retains, as fused to itself, all the metals with which it is combined—indeed, [to the point at which it does] not only *that* but also borders upon the weight of gold (while preserving its own changeable and malleable moistness) and becomes imbued with the fixed and permanent color [of gold].

Orator: Do you think that alchemists can accomplish what they propose to?

Layman: Preciseness remains unattainable; but the weight-scale, without which [alchemists] can do nothing certain, shows how much

they accomplish. For by the verdict of fire and of the weight-scale an examination of this enterprise is possible.

174 *Orator:* Could, likewise, all precious stones be weighed?

Layman: No doubt they could all be weighed by a single technique. For the weight of a diamond in ordered relation to an equal size of lead is different from the weight of a sapphire also in ordered relation to [its own] equal size of lead. And from [this] difference is known the relation between lead and the respective weight of the two stones. A similar thing holds true regarding all other stones. Hence, it would be very useful to have these weights (together with the stones' different origins) recorded in terms of a weight-scale experiment, so that if any tampering were done with a beryl stone or a colored crystal, it could be detected.

Orator: Moreover, the weight of a stone in air is one thing, its weight in water another thing, its weight in oil still another. It would be nice for these differences to be known, so that the difference of weights could be known without the relation to lead or some other third thing.

Layman: Excellently stated.

175 *Orator:* Tell [me] whether it has occurred to you that the *powers* of stones can be weighed by some technique.

Layman: I think that the power of a magnet could be weighed. Suppose that on one side of a balance-scale a piece of iron were placed at equilibrium with a magnet on the other side and that then the magnet were removed but some other heavy object of equal weight were put in its place. Suppose the magnet were held above the iron, so that the piece of iron on the balance-scale were moved upward toward the magnet and (since the iron is [thus] moved out of equality) the weight on the other side became heavier [than the weight of iron—i.e., became heavier] until such time as the iron were to return to an equality [of weight] while the [poised] magnet continued to remain unmoved. I think that by our taking away from the weight [on the side of the balance opposite the iron], the power of the magnet could be said to be proportionally weighed.[13]

Likewise, too, the power of a diamond could be ascertained from the fact that it is said to prevent a magnet from attracting iron. And other powers of other stones [could be ascertained] in their own way—[ascertained] even from the difference of the size of the objects, since there is greater power in a larger object.

176 *Orator:* Could not an artisan discover by experiment how much mercury and how much sulfur each metal contains—and likewise [regarding] stones?

Layman: Assuredly, on the basis of the agreement and the difference of the weights, he would be able to investigate closely all such things. And likewise [he could investigate] the elements of mercury from considering the differences of its weight in air, in water, and in oil—as compared with the weights of the same quantity of water, oil, and ashes. A similar thing holds true for sulphur. So too, through this [technique] he could ascertain, in terms of a quite accurate surmise, the elements of all metals and stones, as well as the weight of [these] elements.

Orator: These [statements] are lovely. Isn't the situation the same with regard to herbs, pieces of wood, pieces of meat, animals, and fluids?

Layman: [Yes,] in all respects, I believe. For example, if a piece of wood is weighed and if after it is burned its ashes are weighed, then there is known how much water was in the wood. For only water and earth have heavy weight.[14] Similarly, from the differences of weight of a piece of wood in air, in water, and in oil we know how much heavier or lighter is the water that is in the wood than is pure water from a spring; [we know], likewise, how much air [was in the wood]. Similarly, [we know] from the difference of weights of the ashes how much fire [was in the wood]. And in these ways the elements are ascertained by a quite accurate surmise, although preciseness is always unattainable. And just as has been stated about wood, so [something similar could be said] about herbs, meats, and other objects.

177 *Orator:* No pure element is said to be observable. [So] how do we experience an element by means of a weight-scale?

Layman: Suppose that after one hundred pounds of earth have been placed in a cask someone were to cull the one hundred pounds successively of herbs or of seeds that were strewn amidst that earth and that were previously weighed [together with that earth]. And suppose that [thereafter] he were to weigh the earth again. He would find that the earth had diminished in weight only a little. From this fact he would know that the collected herbs have weight mainly from water.[15] It follows that thickened waters in the earth have attracted earthenness and that by the activity of the sun the waters have condensed into an herb. If these herbs were burned, wouldn't you—through surmise on the basis of the difference of all the weights—reach [a con-

clusion about] however much earth you would find over and above one hundred pounds?[16] And isn't it evident that water produced this [additional] earth?

Elements are, in part, transformed one into another. For example, in the case of a plate-of-glass placed in the snow, we experience that air on the glass is condensed into water, which we find as a fluid on the glass. Similarly, we experience that a certain [kind of] water is turned into stones (just as water is turned into ice) and that a hardening, petrifying power is present in certain springs-[of-water], which harden into stone objects placed into them. Likewise, there is said to be found a certain kind of water from Hungary that turns iron into copper because of the power-of-glazing that is in that water. From a consideration of such powers it is evident that [the various] waters are not purely elemental things but are things composed of elements. And it would be very delightful to know the weights of the various powers of all such waters, so that from the differences of weight in air and in oil we might make closer surmises about the powers.

178 *Orator:* And likewise regarding earth?

Layman: Yes, indeed, also regarding earth. For one [plot of] earth is fertile, another barren; and in one [plot] there are found stones and minerals, which are not found in another. Therefore, for attaining unto [a piece of earth's] hidden nature, it would be very useful to know the various weights—of different pieces of earth—in water, in air, and in oil. Likewise, from considering the variety-of-weights of grapes, wax, oils, gums, egg-whites, squills, leeks, garlics, and all such things, we can to some extent detect, I believe, the powers that are variously present in them.

Orator: These [weights] could scarcely be written down in an enormous volume.

Layman: Experimental knowledge requires extensive written records. For the more written records there are, the more infallibly we can arrive, on the basis of experiments, at the art elicited from the experiments.

179 *Orator:* Perhaps some day, by means of careful surmises, we might arrive also at the weight of air.

Layman: Suppose that in a location with moderately temperatured air someone placed, on one side of a large weight-balance, much dry, parched wool and placed on the other side [enough] stones to [effect an] equilibrium. [If so,] he would observe that when the air became

more humid the weight of the wool would increase and that when the air became more dry the weight of the wool would decrease. Accordingly, by [recourse to] such a difference he could weigh the air and could make plausible surmises about the change of times.[17]

Similarly, if someone desired to arrive at the sun's various [degrees of] strength in various climatic regions, then if he weighed a thousand grains either of wheat or of barley from very fertile fields of different climatic regions, he would observe from the difference of weights the sun's various [degrees of] strength. For since each of the fields that is at whatever place is equally fertile, and since the number [of grains is equal], the difference could be due only to the sun. Thus, too, we could detect the difference in the strength of the sun on mountain tops and in valleys, along the same line from east to west.

180 *Orator:* If someone were to let a stone fall from a high tower while water were flowing from a narrow opening into a basin and were to weigh the water that flowed during the interval [of the fall], and if, likewise, he were to do the same thing with a falling piece of wood of equal size, then from the differences-in-weight of the water, the wood, and the stone couldn't he arrive at the weight of the air?[18]

Layman: If someone were to do this from different equally high towers and at different times, he could, at length, arrive at a surmise. However, he could arrive at the weight of air sooner by means of a variety of shapes of equal weight. For example, if I were to let a pound of lead in the shape of a sphere fall from a tower while I collected water from a water-clock, and were thereafter to drop a pound of similar lead having a wide shape and were, likewise, to collect the water, then from the difference in the weights of water the weight of the air could be attained. For we know from experience that birds remain more steadily [in the air] when their wings are extended, because the wings occupy more of the air—even as in water, too, a heavy object compacted into a sphere sinks more rapidly than it does when stretched into a square. And just as by means of such a technique the weight of air could be detected, so too could [the weight] of water and, conversely, the various respective capacity of the [various] shapes.

181 *Orator:* I have heard that by a certain technique the depth of the sea [can] be detected.

Layman: Suppose that a piece of lead, formed in the shape of a moon of eight days, were made in such a way that one end were heavier and the other end lighter. And suppose that at the lighter end there

were affixed an apple or some other such light thing—[affixed] in such a way that when the lead drew the apple to the bottom and first touched the earth with its heavier part and began to tilt over, the apple were released from the [lighter] end and returned to the surface.[19] [If so,] then [the desired] knowledge could be obtained by reference to a similar piece of lead, and a similar apple, in another body of water of known depth. For from the difference of weights of the water [collected] from a water-clock—between the time of the tossing of the lead and the return of the apple, in the different bodies of water—the answer to what was being sought would be known.

182 *Orator:* I believe that in this way and in other ways the depth of waters can be investigated. But tell [me]: couldn't also the speed of a ship's movement be surmised in this way?

Layman: In what way?

Orator: Namely, by lobbing an apple into the water from the front [of the ship] and by reference to the flow of water from a water-clock until the apple has reached the stern—and by a comparison of the weights of water [from the water clock] on different occasions.

Layman: Yes, indeed, in that way—or in another way, viz., through the shooting of a crossbow and through the ship's approaching the arrow more quickly or more slowly with reference to the water of the water-clock.

Orator: Also we seem to be able to investigate, in a proportional way, the strength of bows and crossbows—[doing so] by means of the flow of water from a water-clock from the point of time at which the arrow is sent straight upwards [until it] returns to the earth, [and doing so] in such a way that in different crossbows the arrow is [of] equal [length and weight].

Layman: The strength of crossbows and cannons—indeed, the strength of winds and likewise the strength of the hunting-prowess of men and of animals and the strength of military forces and [of] what[ever other] similar thing can be mentioned—can be investigated, in a surmising way, from experiments done with weight-scales and from the flow of water from a water-clock.

183 *Orator:* How will a man's strength be known?

Layman: Ascertain how much weight—placed on one side of a weight-balance—the man can elevate to equilibrium by pulling down on the other, empty side of the balance. Then deduct the man's weight from the weight he has elevated. The remainder of the thing's weight

is proportional to the man's strength.

Orator: So too, the man's breath could be weighed.

Layman: The weight of a man who takes in a breath and holds it is different from that of a man who exhales; and the weight of a living man is one thing, that of a dead man another thing; the situation is similar in the case of all animals. Hence, it would be lovely to have these differences recorded with regard to different animals, different men, and different ages of men, so that our surmising could attain unto the weight of [those] breaths-of-life.

184 *Orator:* Could we not detect, in such a way, the heat and the cold and the dryness and the moistness during a period of time?

Layman: We surely could. For example, if during a cold period you note the weight of water both before its becoming frozen and afterwards, you will find the weight to be different. For when you see ice floating on the water, you know that it is lighter than the water. Hence, the variation in the weight is greater in proportion to the intensity of the cold. So too, if during a warm spell you expose water to the air, the weight varies according to the weather. Or, again, if you weigh green wood and after a certain time find that its weight has changed, then from this [finding] you will know the increased amount of cold or of heat—and likewise [the increased amount] of moistness and of dryness.

Orator: Couldn't even the time of the day be weighed in this way?

Layman: If you collect water from a water-clock from sunrise to sunrise and weigh it, and if, on another day, you make the water flow from sunrise, then from the proportion of the weight (of [this] outflow) to the first weight, you can know the hour and the time of day.

185 *Orator:* Perhaps, too, regarding the time of year?

Layman: Yes, indeed. If throughout the year, by means of a water-clock, you keep a record of all the days from sunrise to sunset, you will always be able to ascertain, by surmises from the weight-scale, both the day of the month and the hour of the day—although on those days when the variation is small because of the days' brevity, [you will ascertain something] less assuredly than on the other days.

Orator: I see that by such a technique we can attain unto the motion of the heavenly bodies, as Nimrod[20] is reported to have done and as Hipparchus[21] is reported to have written about.

Layman: What you say is right, although in this case there is need

of careful calculation. For example, if someone, having taken note of a fixed star on a meridian were to collect water from a water-clock until the return of the star [to the same spot], and if he were to do something similar regarding the sun from sunrise to sunrise, then he could determine the movement of the sun toward the east from considering the difference of the smaller-weight-of-water [as regards a comparison] of (1) the movement of the star from the meridian until its return to the same meridional point and (2) the movement of the sun from sunrise to sunrise.[22] For the less water there would be [in the case of the star] as compared to the weight of the entire [amount of water], the more [the sun] would be moved in ordered relation to the equinoctial circle,[23] not the zodiac circle, which is described not with respect to the earth's poles but with respect to its own. Likewise, if by reference to the same star someone wanted to find out how much the sun was moved in fifteen days, he could do this, in the same manner, from considering the various distances of the sunrise in ordered relation to the location of the star on a meridian. For example, if today the distance of the location of a star on a meridian—[the distance] from the sunrise—is determined by a water-clock to be in a certain proportion to the weight of the water for the entire revolution of the star, and in another fifteen days [there is determined to be] another proportion, then from [this] difference the movement [of the sun] could be ascertained—[ascertained] always with regard to the equinoctial [circle].

186 *Orator:* Can movement in the zodiac be ascertained in this way?

Layman: Yes, it certainly can—through the movement of the sun from meridian to meridian and from east to east and from east to west. For from these differences the veering of the zodiac from the equinoctial circle could be ascertained.

Orator: What about the difference of movement that is said to occur because of an eccentric orbit?

Layman: Even that will be ascertained, when during the year an inequality in the zodiac will be ascertained in the [two] equinoctial periods. For it is not the case that the sun, having been moved from the equinoctial circle, returns to the equinoctial circle in the same number of days in the summer as in winter, when [this movement] occurs more quickly. For the sun would be found not to have wandered for as many days from Libra to Aries as from Aries to Libra. From this difference the eccentric orbit—i.e., the small circle of difference-of-movement—would be made evident.

187 *Orator:* What about the physical size of the sun?

Layman: From a consideration, on an equinoctial day, of the weight of flowing water (in a water-clock) from the beginning of a sunrise until the sun as a whole is above the horizon, in relation to the [weight of] water pertaining to the revolution of a star, a close approximation is had of the sun's physical size as regards its own sphere. Nevertheless, in another way, the sun's size can be detected by reference to solar eclipses.

Orator: How?

Layman: We [begin by] ascertaining the movement of the moon in the way in which [we ascertain the movement] of the sun. Next, from an eclipse of the moon and from the movement of the moon through the shadow of the earth we detect the moon's size in ordered relation to the varied shadow of the earth. Herefrom we surmise that the proportion of the moon's size to [that of] the earth is 1:2. Next, by means of an accurate, though surmising, technique we detect—on the basis of the movement of the moon and the eclipsing of the sun—both the distance of the sun from the earth and the sun's size.

Orator: From what you have said, it seems that all the different movements and eclipses of luminary heavenly bodies—indeed, all the progressions, positions, retrogressions, west-to-east movements, and eccentric movements of all planetary bodies—can be attained by you by one and the same technique of [recourse to] the weight-scale and the water-clock.

Layman: You too will [be able to] act similarly if you strive to collect accurately the differences [of weight].

188 *Orator:* What about the verdicts of the stars?

Layman: I think, too, that from the variety of weights of water in different years and from certain other differences (in different years) of the weights of pieces of wood and of herbs and of grains of wheat it is possible to surmise future fertility or dearth on the basis of past experiences—[possible, that is, to surmise these] more quickly than on the basis of the movement of the stars. For example, if in March the weights of water and of air and of pieces of wood are found to be present in a certain degree, then from the earth fertility will follow; if otherwise, then barrenness or moderate yield will follow. A similar thing holds true regarding wars, pestilence, and all such common occurrences. And this [assessment of weights] is the basis on which we make a judgment about the stars, as regards these secondary stars[24]—as when from [an assessment] of the marrow, or pith, in animals, fish,

crabs, trees, and reeds we detect the stage of the moon, and as when we detect the moon's location by reference to the tidal flow of the ocean.

189 *Orator:* I have heard that from the overflowing and the deficit of the Nile the Egyptians foresee the disposition of the year.

Layman: There is no region such that if someone were to take note of it he would not find similar judgments—just as from the fatness of fish and of reptiles at the beginning of winter we surmise a severe and prolonged period of cold, against which wise mother nature has made provision in the case of animals.

Orator: What about the questions that are posed to astrologers? By means of your technique could a satisfactory answer to all [of them] be found?

Layman: I think that a certain answer could be given, although one not fully satisfactory. Yet, the way in which a surmising response could be given to the questions put [to astrologers] requires an extensive inquiry. There is no suitable way [for a surmise] to be made from weights, even though it is perhaps the case that the one giving the answer can gauge the weightiness of a [suitable] response only from the weightiness of the question. For the motivation for the questioning, on the part of the one posing the question, seems to be produced from a certain foreseeing of a future event, although [the questioner] does not see the source from which he is being motivated—even as someone who feels in his eye something that he does not see seeks from someone else that [this other] look to see what is wrong.

190 *Orator:* I think you mean that a judgment is supposed to be reached just as on a Pythagorean wheel[25] a means of finding answers is provided from the various combinations of (1) the name of the inquirer's mother, (2) the hour of the day, and (3) the light of the moon—or as a seer [judges] from lots or from a chance reading from books of the Sibyls or of a psalter or from the configurations of heavenly bodies or from geomantic shapes or from the chirping of birds or from the dancing of a flame of fire or from a relation to a third thing or from some chance occurrence.

Layman: And there were those who detected a response indirectly, from a conversation that they had with the questioner in referring to recent events concerning the disposition of the nation, (as if an impulsive spirit manifested itself in the protracted conversations). For example, if the conversations turned to sad affairs, then they

thought such [sadness] would be the outcome of the matter; and if the conversations turned to happy affairs, then [they thought that the outcome would be] happy. However, when I have paid attention to [someone's] countenance, his clothes, his eye-movements, to the form of his words and their weightiness, to the state of things that I requested him to make known to me, at repeated moments, then I have suspected that surmises could be made. However, more precise surmises [can be made] by one to whom something quite true comes to mind unreflectingly—someone in whom a certain presaging spirit seems to speak. However, I think that with regard to this [predictive activity] no [structured] art is possible and that the one who has [this] sense-of-judgment cannot pass it on and that a wise man ought not to busy himself with these [predictive activities].

191 *Orator:* Very well stated. For St. Augustine reports[26] that in his own day there was a man given to drink to whom the thoughts of [others'] minds were evident. And [that man] exposed thieves and brought to light, in an amazing way, other hidden matters—although he was very flighty and not at all wise.

Layman: I know that I have often foretold many things, according as my spirit brought [them] to mind; and yet, I did not at all know the basis for [my prediction]. In the end, it seemed to me not to be permitted to a serious man to speak without a basis, and I thenceforth kept silent.

192 *Orator:* Now that enough has been said, it seems, about these movements of the stars, add something also about musical sounds.

Layman: Experiments done with weight-scales are very useful with regard to music.[27] For example, from the difference of the weights of two bells of consonant tone, it is known of which harmonic proportion the tone consists. Likewise, from the weight of music-pipes and of the water filling the pipes there is known the proportion of the octave, of the fifth, and of the fourth, and of all harmonies howsoever formable. Similarly, the [harmonic] proportion—from the weight of mallets from whose striking on an anvil there arises a certain harmony, and from the weight of drops dripping from a rock into a pond and making various musical notes, and from the weight of flutes and of all musical instruments—is arrived at more precisely by means of a weight-scale.

193 *Orator:* So too, [as regards the harmonic proportion] of voices and of songs.

Layman: Yes, all concordant harmonies are, in general, very accurately investigated by means of weights. Indeed, the weight of a thing is, properly speaking, a harmonic proportion that has arisen from various combinations of different things. Even the friendships and the animosities of animals (and of men) of the same respective species—as well as their customs and whatever [other] such thing—are weighed from harmonic concordances and from opposing dissonances. Likewise, too, both a man's health and his lack of health are weighed in terms of harmony—and so too are his flightiness and seriousness, his prudence and naiveté, and many other such things, if you pay careful attention.

194 *Orator:* What do you think about geometry?

Layman: I think that (1) the close proportions between a circle and a square[28] and (2) all other things that pertain to figures' different capacities can be experienced more suitably by means of weights than by any other means. For example, if you make a cylindrical vessel of a known diameter and height, and make a second, cubical vessel of the same diameter and height, and fill them both with water and weigh them, then you will know, from the difference of weights, the proportion of an inscribed square to the circle within which it is inscribed. And thereby there will be known to you, in terms of a close surmise, the squaring of the circle[29] and whatever else in this regard you desire to know. Likewise, if you take two sheets of completely equal metal and bend one of them into a circle by making a cylindrical vessel, and if you form the other one into a square by fashioning a cubical vessel, and if you fill the vessels with water, then you will know from the difference of their weights the difference-in-area between a circle and a square of equal perimeter. Likewise, if you have more than one such sheet of metal, you will be able to investigate the different capacities in the case of a triangle, a pentagon, a hexagon, and so on. Similarly, by means of [considering] weight, you will be able to attain unto the art of the capacities of any shape of vessel whatsoever and unto [an understanding of] the instruments of measuring and of weighing—attain unto (1) how weight-scales are made and (2) how one pound elevates a thousand pounds in proportion to its distance from the center and in proportion to its various straighter or more curved [arc of] descent and (3) how all the subtle devices of ships and of machines are to be made. Hence, I think that experimentation done with weight-scales is very useful for all things pertaining to geometry.

195 *Orator:* You have now explained sufficiently the reasons why you wish for the weights of things to be measured by means of a weight-scale and to be recorded both serially and multiply. For, indeed, we see that that book would be very useful. And we see that the undertaking of it by great men ought to be urged, so that in different provinces [experimental weights] would be registered and would be collected into one [book], so that we would more readily be brought to many things that are [now] hidden to us. And I will not cease everywhere to promote its being done.

Layman: If you care for me, then be diligent [in this task]. Farewell.

ABBREVIATIONS

Ap. *Apologia Doctae Ignorantiae* [Vol. II (edited by Raymond Klibansky) of *Nicolai de Cusa Opera Omnia* (Leipzig/ Hamburg: F. Meiner Verlag, 1932)].

CA *Cribratio Alkorani* [Vol. VIII (edited by Ludwig Hagemann) of *Nicolai de Cusa Opera Omnia* (Hamburg: F. Meiner Verlag, 1986)].

DI *De Docta Ignorantia* [Latin-German edition: *Schriften des Nikolaus von Kues in deutscher Übersetzung*, published by F. Meiner Verlag. **Book I** (Vol. 264a), edited and translated by Paul Wilpert; 3rd edition with minor improvements by Hans G. Senger, 1979. **Book II** (Vol. 264b), edited and translated by Paul Wilpert; 2nd edition with minor improvements by Hans G. Senger, 1977. **Book III** (Vol. 264c); Latin text edited by Raymond Klibansky; introduction and translation by Hans G. Senger, 1977].

DM *Idiota de Mente* [Contained in Vol. V (edited by Renate Steiger and Ludwig Baur) of *Nicolai de Cusa Opera Omnia* (Hamburg: F. Meiner Verlag, 1983). Replaces Baur's edition of 1937.]

DP *De Possest* [Latin text as contained in J. Hopkins, *A Concise Introduction to the Philosophy of Nicholas of Cusa* (Minneapolis: Banning, 3rd ed. 1986)].

DVD *De Visione Dei* [Latin text as contained in J. Hopkins, *Nicholas of Cusa's Dialectical Mysticism: Text, Translation, and Interpretive Study of De Visione Dei* (Minneapolis: Banning, 2nd ed. 1988)].

MFCG *Mitteilungen und Forschungsbeiträge der Cusanus-Gesellschaft,*edited by Klaus Kremer and Klaus Reinhardt. A continuing series. Volumes I-XVII published in Mainz, Germany by Matthias-Grünewald Verlag. Volumes XVIII and higher published in Trier by Paulinus-Verlag.

NA *De Li Non Aliud* [Latin text as contained in J. Hopkins, *Nicholas of Cusa on God as Not-other: A Translation and a Appraisal of De Li Non Aliud* (Minneapolis: Banning, 3rd ed. 1987)].

PL *Patrologia Latina*, edited by J.-P. Migne. Series published in Paris.

SCG Thomas Aquinas, *Summa contra Gentiles* [in Vol. II (1980) of *Index Thomisticus. Sancti Thomae Aquinatis Opera Omnia*. Stuttgart-Bad-Cannstatt: Frommann-Holzboog Verlag].

ST Thomas Aquinas, *Summa Theologiae* [in Vol. II (1980) of *Index Thomisticus, ibid.*].

VS *De Venatione Sapientiae* [Vol. XII (edited by Raymond Klibansky and Hans G. Senger) of *Nicolai de Cusa Opera Omnia* (Hamburg: F. Meiner Verlag, 1982)].

PRAENOTANDA

1. (a) In the English translations brackets are used to indicate words supplied by the translator to complete the meaning of a Latin phrase, clause, or sentence. (b) When a clarifying Latin word is inserted into the translation, brackets (rather than parentheses) are used if the case ending or the verb-form has been modified. (c) In the Latin text brackets indicate that a word or phrase found in the mss. should be deleted.

2. All references to Nicholas of Cusa's works are to the Latin texts in the following editions (unless explicitly indicated otherwise):

A. Heidelberg Academy edition of *Nicolai de Cusa Opera Omnia* (Felix Meiner Verlag: Hamburg): *De Concordantia Catholica; Sermones; De Coniecturis; De Deo Abscondito; De Quaerendo Deum; De Filiatione Dei; De Dato Patris Luminum; Coniectura de Ultimis Diebus; De Genesi; Apologia Doctae Ignorantiae; De Pace Fidei; De Beryllo* (1988 edition)*; Cribratio Alkorani; De Principio; De Deo Unitrino Principio; De Theologicis Complementis; De Venatione Sapientiae; De Apice Theoriae.*

B. Texts authorized by the Heidelberg Academy and published in the Latin-German editions of Felix Meiner Verlag's series *Philosophische Bibliothek*: *De Docta Ignorantia*.

C. Editions by J. Hopkins: *Idiotae de Sapientia, de Mente, de Staticis Experimentis* (1996)*; De Visione Dei* (1988)*; De Possest* (1986)*; De Li Non Aliud* (1987)*; Compendium* (1996). Margin numbers correspond to the margin numbers in the Heidelberg Academy editions; line numbers and some paragraph-breaks differ.

D. Codex Cusanus Latinus 219: *De Ludo Globi*.

E. Paris edition of the *Opera Omnia Cusani* (1514)*: De Aequalitate*.

The references given for some of these treatises indicate book and chapter, for others margin number and line, and for still others page and line. Readers should have no difficulty determining which is which when they consult the particular Latin text. E.g., '*DI* II, 6 (125:19-20)' indicates *De Docta Ignorantia*, Book II, Chapter 6, margin number 125, lines 19-20 of the edition in the series *Philosophische Bibliothek* (Hamburg: Felix Meiner Verlag).

3. The folio numbers in the inside margins of the present edition of the Latin text of the *Idiotae* and the *Compendium* correspond to the folios in Codex Cusanus Latinus 218 (*Idiotae*) or 219 (*Compendium*).

4. References to the Bible are given in terms of the Douay version. References to chapters and verses of the Psalms include, in parentheses, the King James' locations.

5. Italics are used sparingly, so that, as a rule, foreign expressions are italicized only when they are short. All translations are mine unless otherwise specifically indicated.

6. The Appendix serves as a supplement to the respective bibliographies found in the present book and in four other books: (J. Hopkins) *A Concise Introduction to the Philosophy of Nicholas of Cusa* (1986[3]); *Nicholas of Cusa on Learned Ignorance* (1985[2]); *Nicholas of Cusa's Dialectical Mysticism* (1988[2]); *Nicholas of Cusa's De Pace Fidei and Cribratio Alkorani* (1994[2]).

7. Citations of Nicholas's sermons are given in terms of the sermon numbers assigned by Rudolf Haubst in fascicle 0 [=zero], Vol. XVI of *Nicolai de Cusa Opera Omnia* (Hamburg: F. Meiner Verlag, 1991). Not all of the sermons cited have as yet been published in the *Opera Omnia* series.

8. In the notes to the Latin texts no mention is made of trivial marginalia by later hands (such as 'nota quod' on folio 113[r], Codex Cusanus 218).

9. The present edition of the Latin texts follows, principally but not uncritically, Codices Cusani 218 and 219. At places, it differs significantly from the Heidelberg Academy editions. Several examples from *De Mente* will illustrate this fact:

Heidelberg Acad. Text (1983)	Present text
DM 7 (100:13): spiritui	(100:16-17): spiritus
DM 12 (144:15): inhabitante	(144:19): inhabitantem
DM 13 (148:6): habens	(148:7): habentem
DM 13 (149:5): imaginis	(149:6): imago

The punctuation of the present edition will also, at times, reflect an understanding that differs from the understanding implicit in the punctuation found in the Heidelberg Academy texts.

10. Codex Monacensis Latinus 14213 (Staatsbibliothek, Munich, Germany) and Codex Magdeburgensis Latinus 166 (presently in the Deutsche Staatsbibliothek, Berlin) are described in *Nicolai de Cusa Opera Omnia*, Vol. IV (Hamburg: Meiner, 1959).

NOTES TO *IDIOTA DE STATICIS EXPERIMENTIS*

1. This work, written while Nicholas was in Fabriano, Italy, was finished in the first half of September 1450. (The various manuscripts give September 9, 13, and 14 as the date of completion.) The kind of weight scales that Nicholas refers to are balances. The title in Codex Cusanus Latinus 218 uses the genitive case of "*Idiota*" (viz., "*Idiote*," i.e., "*Idiotae*") and is a shortened version of "*Dialogus Idiotae de Staticis Experimentis*."

2. The reference is to the orator who is also a discussant in *De Mente* and *De Sapientia*.

3. Though Nicholas uses the singular "*statera*," the meaning is here better expressed in English by use of the plural "weight-scales." The same thing holds true regarding "*instrumentum*" in the subsequent line.

4. The notion of 'knowing by means of surmises' is not a bizzare notion for Nicholas. That which we ordinarily call knowledge Nicholas refers to as *surmise*, thereby indicating that it is not *precise* knowledge—something possessed only by God. Along with the rest of us, Nicholas sometimes speaks in the ordinary way because some "surmising" is the equivalent of what we ordinarily call "knowing".

5. Proverbs 16:11. Wisdom 11:21-23. Proverbs 8:28-29.

6. Marcus Vitruvius Pollio was a Roman architect and engineer under Julius Caesar and Augustus Caesar.

We may presume that most of the points that Nicholas makes in *De Staticis Experimentis* are not original with him. He seems to have been influenced by ideas from manuscripts that he collected and by ideas in circulation among his scholarly acquaintances—e.g., ideas expressed by Leon Battista Alberti in the latter's *De' ludi matematici* and possibly in his *De motibus ponderis* (now lost). See, above, n. 297 and n. 316 of Notes to the Introduction. Avicenna's *Liber Canonis Medicinae,* with which Nicholas must have been familiar, refers to the different pulse-rates of the young and the old and of the different quantities of urine-output of the sick and the healthy. Cf. *De Staticis* 164-165. And note the discussions of pulse and urine in Codex Cusanus Latinus 293.

7. In the corresponding Latin sentence I follow Codex Cusanus Latinus 218, which has " … *quam et fallaci colore*" and not " … *quam ex fallaci colore*". Nicholas does not always repeat a preposition after "*quam*". Cf. *De Staticis Experimentis* 164:5 and 165:5-7.

8. The one word "breathing" satisfactorily translates "*spiritum seu anhelitum*".

9. " … an animal of the same proportion": i.e., an animal that would be as heavy as a man if only it were the same size as the man.

10. Nicholas was familiar with this widely known Archimedean principle. Leon Battista Alberti discusses it in *De' ludi matematici* 20.

11. Pure gold is *aurum obrison*. Job 28:15.

12. Both fire and air, being elements, have weight, says Nicholas; but they do not have heavy weight but rather light weight, because their presence in earth or water make these latter lighter. The various weights of fire are detectible from the varying

speeds with which the flames of fire move upward. See *De Staticis Experimentis* 176:16-20 and 180:4-6.

According to Nicholas the four elements are earth, air, fire, and water. This was the standard view in ancient and medieval times.

13. " … proportionally weighed": i.e., the strength of the magnet would be weighed by reference to the amount of weight that had to be removed from the depressed side of the balance in order to bring both sides into an equilibrium.

14. See n. 12 above and n. 15 below.

15. Water is lighter than earth. If herbs were mainly of earth, then after the removal of the herbs from the pile of earth, the pile would weigh even less than turns out to be the case. See n. 12 above.

16. Air and fire would have left the wood, leaving the residue heavier, since air and fire work counter to the heavy weights earth and water. See n. 12 above.

17. The expression "change of times" includes reference not just to seasons but to times of the day or night, as well, and to changes in weather conditions on different days—or on the same day. Therefore, the corresponding Latin expression should not be translated as "change of seasons."

18. Air is explicitly said to have weight, though it does not have *gravitas*—that is, heaviness. See n. 12 above.

19. We might envision the apple as nestled into a cove on the lighter end of the crescent-shaped lead object. It would remain in the hollow only as long as the piece of lead were sinking, for only then would the lead remain in an "upright" position.

Cf. Leon Battista Alberti, *De' ludi matematici* 8.

20. Re Nimrod, descendant of Noah and legendary founder of Babylon, see Augustine, *De Civitate Dei*, Book 16, Chap. 4. Scriptural references include Genesis 10:8-10, I Chronicles 1:10, and Micah 5:6.

21. Hipparchus, the Greek astronomer, flourished during the second century B.C. Born in Nicaea, he spent much time on the island of Rhodes. His sole extant work is *In Arati et Eudoxi Phaenomena* [edited by Karl Manitius (Leipzig, 1894)].

22. The sun appears to revolve around the earth from *east to west* (i.e., "with the firmament") once every day. At the same time, the sun actually moves among the stars from *west to east* (i.e., "counter to the firmament"), making one complete circuit of the heavens in a year. Because the sun changes its position in the heavens constantly at a uniform rate, it requires a few more minutes than do the stars to complete its daily apparent revolution about the earth. A similar effect is generally true for the planets as well.

Nicholas, of course, was thinking in terms of the Ptolemaic system, so that he regarded the sun's motion around the earth as real, not as apparent.

See Karel Hujer, "Nicholas of Cusa and His Influence on the Rise of New Astronomy," pp. 87-92 in *XII^e Congrès International d'Histoire des Sciences Paris 1968. Actes*. Tome III A, *Science et philosophie: Antiquité - Moyen Age - Renaissance*. Paris: Albert Blanchard, 1971.

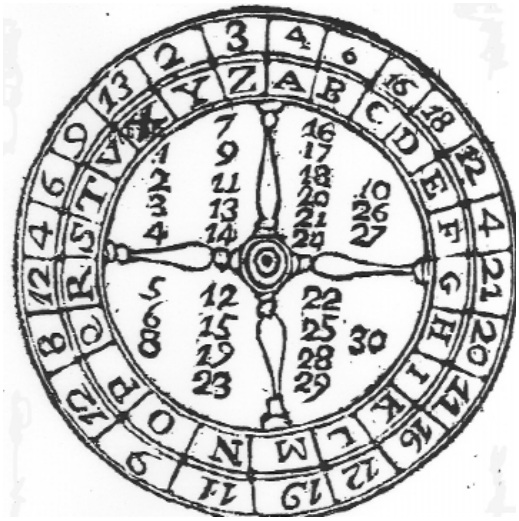
23. For a brief contemporary account, see the entry "equatorial coordinate system" in *The Columbia Encyclopedia* (New York: Columbia University Press, 1993), p. 884.

See also John L. Dreyer, *A History of Astronomy from Thales to Kepler* (New York: Dover Publications, 2nd ed., 1953).

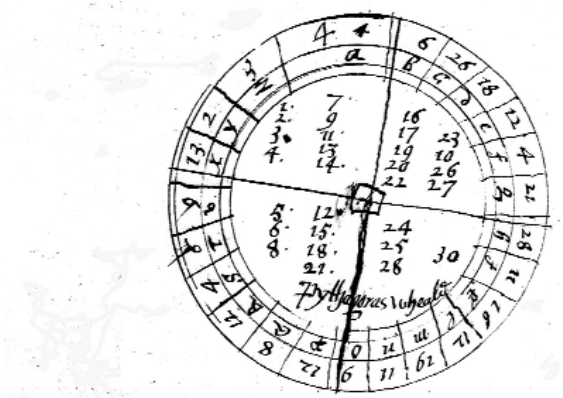
24. The "secondary stars" are the planets and their moons.

25. See Ernst Zinner, *Die Geschichte der Sternkunde von den ersten Anfängen bis zur Gegenwart* (Berlin: Springer, 1931), p. 381. In another regard, see also Zinner's discussion of water-clocks (pp. 78-81). See also his explanation of the ancient Greeks' conception of the size of the sun and of the moon (pp. 95-97).

In addition, note Erra Pater's *The New Book of Knowledge* (Boston, 1767), pp. 158-161. On p. 158 there is a diagram of Pythagoras's Wheel.



A somewhat different diagram is found on folio 66^{v} of manuscript Marshall 15 of the Bodleian Library at Oxford University.



26. St. Augustine, *Contra Academicos* I. 6. 18 (*PL* 32:915).

27. *DM* 6 (91).

28. *DM* 6 (91), including note 49 of Notes to *Idiota de Mente*.

29. See Nicholas's *De Circuli Quadratura* (in the Basel edition of Nicholas's works). Translated into German by Josepha Hofmann in *Nikolaus von Kues. Die mathematischen Schriften* (Hamburg: Meiner, 1979, 2nd ed.).