

APPENDIX I:

The Irish ASTRONOMICAL TRACT

A Revised English Translation

Preface

Two complete English translations of the Tract have been made to date. The first was undertaken by John J O'Farrelly in 1893. A hand written copy and a typed copy are in the archives of the Royal Irish Academy, Dublin. O'Farrelly had considerable technical advice from Maxwell Close, at that time Treasurer of the Academy. Close's knowledge of the history of astronomy was thorough and his assistance would have been substantial. The typed copy in the Academy Library carries with it Close's handwritten commentary on the blank facing pages. The commentary was completed in 1901. Neither the translation nor the accompanying commentary has been published.

The translation of Maura Power was completed in 1914 under the direction of Bergin. It was published later that year by the Irish Tract Society. Her translation was made without reference to the earlier work of O'Farrelly and Close. As with the earlier translation it is based principally on the Irish of Stowe B, with reference to both the Marsh copy and the second RIA copy where correlation was possible.

The following English edition of the Tract is substantially that of Power. In various places however, Power's translation ranges from obscure to contradictory, largely through an apparent lack of familiarity with the subject matter. In these parts, reference to O'Farrelly's translation invariably restores the intended sense of the passage. Using the work of Close and O'Farrelly, I have amended Power's translation in minimalist fashion. The required 'substantial' changes are all acknowledged in footnotes.

In addition, numerous 'minor' changes have been made to technical terminology that was ill fitting in Power's work. For example, the term *Pol Airtic*, is invariably translated as 'Arctic Pole'. This is quite misleading to a contemporary reader, since in the geocentric framework of Ptolemaic astronomy, the pole refers to that of the celestial sphere. In Chapter 35, we are told that the *Pol Airtic* can be viewed from the equator at an elevation of zero degrees, i.e., on the horizon. The author clearly refers to the North Celestial Pole. Reference simply to the Arctic Pole is hence, an apparent impossibility. To avoid this confusion, I have used the term Arctic (Celestial) Pole.

Another frequent point of confusion in Power's text arises from the fact that the Irish term *cercall* can variously mean 'orbit', 'circle' or 'sphere'. Power generally opts for the term 'orbit' when it refers to celestial matters. This has often been inappropriate. Chapter 16 deals at length with imaginary grid lines that define the celestial chart; 'meridian' and so forth. I have used the word 'circle' in such cases. I have retained the term 'orbit' only when it applies to the path of a planet, moon or sun, in accord with a geocentric model. A further variation occurs in Chapter 29 of the Tract where the term is also used as an alternative to *speir*, meaning a celestial sphere in Ptolemaic terminology. A rather isolated use of the term *cercall* is employed in a description of Cleomedes's analogy of the potter's wheel. In this case it refers to the movement of small balls along grooves on the wheel. Power's use of the word

‘circle’ merely serves to obscure the analogy. It seem neither she nor Bergin was familiar with the earlier analogy.

A slightly irritating element of O’Farrelly’s and occasionally Power’s translation, has been the retention of the personal pronouns when referring to celestial objects such as planets and the sun or moon, the sun being ‘she’ and planets such as Mars and Jupiter being ‘he’. While it sits comfortably in the Irish, its retention in an English translation can be misleading. I have therefore removed these accidental tags of Irish grammar.

A similar problem results from the variations in Irish terminology for the planets, stars and constellations. This has often let to confusion in Power’s English translation. For example, in a passage describing the period of Saturn’s orbit, the planet is referred to as the *retlann* (star). The reference to the planets as stars was not new in Irish (or Latin for that matter), during the Middle Ages, but the use of the English word ‘star’ when referring to a planet would be misleading to contemporary readers.

‘Minor’ alterations such as these have not been footnoted.

In a few places, there has been obvious corruption of the text. In Chapter 7 for example, it appears that a whole line of text had slipped from an early transcription. Close supplied the gist of this missing line and I have included it in italics, suitably footnoted. In Chapter 22 another obvious corruption of the text seems to have resulted from faulty restoration of contracted verbs. By changing the verbs to conditional mood, O’Farrelly was able to redeem the intended meaning. I have included these amendments in this translation.

For some reason, numerical terms have been very prone to scribal error.¹ Some, such as that for the angular displacement of the sun and moon at the end of Chapter 25 date back to early times in the life of the Tract. Another in Chapter 21 seems to have slipped past the print proofs of the ITS publishers. The angle in the Irish text is correct, but the English one in error. I have made these corrections, duly footnoted.

Concerning the value of π , Power expressed surprise that the Irish author had taken it as being 3 rather than $3\frac{1}{7}$. Assuming it to be a scribal error, Power corrected it to conform to the traditional value. The calculations within that Chapter however, take π to be simply 3. I have left it as such, for it is quite clear that this was the value used by the author.

I have retained the almost all of the diagrams as they appear in the ITS publication. In the case of Figure 6, I have substituted the amended version of Maxwell Close. Both the Stowe B and Marsh version are distorted to the point of obscuring its meaning. The diagram of Close conforms to the Irish text and the equivalent diagram in the Latin edition of Stabius. One or two other

¹ It is interesting to note that Power and O’Farrelly differed in several places in their transcriptions of the numerical data from the cover sheet of MS Stowe B II. This uncertainty partly derives from the late medieval practice of indiscriminantly using both Roman & Hindu-Arabic numerals.

diagrams have suffered distortions almost as severe, at the hand of subsequent scribes, but I have retained these as per the ITS publication. Figure 20 is one such case. The corresponding figure in the Stabius edition of the Latin is also corrupted and this seems to have led to confusion in the Irish text as well. This corruption of the text at the hand of the author has been retained.

In spite of these amendments, the following English translation remains substantially a re-edition of Power's work, hopefully with its confusions and contradictions rectified.

I have included most, but not all, of Close's commentary to the Tract by way of footnotes. He was on occasion prone to elaborate in minute detail on elements that were rather tangential to the main body of the Tract. A few I have omitted, some I have curtailed. The occasional footnote from Maura Power has also been included. I have added additional footnotes where appropriate. The footnotes of Power and Close are all acknowledged.

* * *

GLORIA DEO PRINCIPIO¹

Glory to God; whose beginning is without beginning, and whose end is without end, to the Person who existed always before everything, who will be eternal after everything, and to Him whom sense or human reason does not attain, to know or recognise what He is.

And since he did not wish to remain for ever without manifesting Himself to men, He instructed the learned in His works and arts, so that the worker would be known from the works and the creator from the deeds, and therefore, it is fitting for the learned ones to whom He revealed His secrets to glorify Him above everything.

Therefore, let us here begin to examine the difficult, obscure questions of the ancients concerning the works, and in particular [we discuss], with the help of the Creator of whom I speak, the characteristics of the firmament and of the four elements, and of their situation and their creation, with very just, forcible arguments and indisputable, irrefutable reasons and conclusions.

There are in this book, inclusive, forty chapters, and this is the first chapter of them: -

The creation and manifestation of the firmament.	(1) ²
The four elements and their positions as the Creator ordained them.	(2)
Their motions and natures.	(3)
Their natures and motions. ³	
The roundness of the four elements.	(5)
The disagreement of the four elements and the nature of them.	(6)
The rotundity of the earth and the knowledge of day and night.	(7)
The change of the sea and the rivers.	(8)
The characteristics of the earth and the hills.	(8)
The characteristics of the waters and the motion of the earth.	(9)
The two burning volcanoes.	(10)
The flow and ebb of the tide.	(11)
The flood of the river Nile in Egypt.	(12)
The roundness of the firmament; its motion and its natures.	(13)
The revolution of the firmament and of the sun.	(14)
The change of the firmament.	(15)
The circles lines and points of the firmament.	(16)
The difference in sunrise and sunset.	(17)
The knowledge of the size of the sun.	(18)
The light of the moon, which borrows from the sun.	(21)
The eclipse of the moon.	(22)

¹ Needless to say, this prologue is not to be found in Stabius' edition of the Latin translation of Messahallah. (JW)

² The numerals in italics correspond to Chapters of the Tract as numbered by Power. I have retained Power's divisions in this edition. (JW)

³ This is an obvious transcriptional error in ms Stowe B. It should read; *The Principal Properties of the Four Elements*. The scribe, (or author of this Introduction) has inadvertently repeated the theme from the preceeding chapter. (JW)

The light of the constellations.	(23)	
The eclipse of the sun.	(24)	
The reason why the moon appears small, and large at its prime.	(25)	
The characteristics of the light of the moon.	(26)	
The number of circles of the moon.	(27)	
The two spheres of the sun.	(28)	
All the circles and their motion.	(29)	
The motion of the Great Sphere.	(30)	
The motion of the Sphere of the Signs.	(31)	
The change of nature and the seasons.	(31)	
The number of the circles of Saturn and the other planets.	(32)	
The retrograde movement of Saturn and the other planets.	(32)	
The Sphere of the Stars.	(34)	
The number of miles around the earth.	(35)	
The change of the stars in different countries. ¹		
The eight habitable regions of the earth.	(36)	
The two places where the whole year is one day and one night.	(37)	
The winds and their nature.	(38)	
Thunder, clouds, rain and lightning.	(39)	
The plants.	(40)	

* * *

1. FIRMAMENTUM EST, ET CETERA.²

The firmament is round according to its creation, and will come to an end, and is ever ruled by its own Creator.

There are stars in the seven spheres of the firmament, like firm nails in a plank, without motion of their own, except the motion of the circle in which they are. On that account they are not seen moving past each other or after each other, but they always preserve one constant, everlasting order at fixed distances to and from each other.

As a proof that that government is preserved by the Creator of the world, and that it will depend upon His works for ever, they observe without deception and without fail the course He ordained for them at the beginning of the world.

As a proof of that, the learned have knowledge of every natural phenomenon before it occurs, for they understand fully the motion of the stars and of the planets for every year and every month and every week and for every day and every moment. And besides they even have knowledge of the seasons before they are entered upon, knowledge of summer and autumn, winter and spring, and knowledge of everything that occurs naturally in them; and that is a sure argument to prove that He who created the world is still governing it, otherwise the things I have mentioned would have altered by this the function

¹ This heading does not seem to correspond to any of the extant Chapters. It would appear to have slipped from the Tract in early days. (JW)

² “This Chapter is very different from Chapter 1 in Stabius’ edition of the Latin; thought the two chapters unquestionably correspond.” (Close)

I related them to have; the stars and the planets would be each, at one time swifter, at another, slower than the other, and at another time stationary, not stirring at all.

In the same manner the seasons would come (one) instead of another, and there would be natural days longer than one another. And, accordingly, the fruits of the earth would be growing at one time and at another time would be non-productive. Accordingly, everything in heaven and earth would be confused and confounded, neither philosopher or seer knowing what to say of them. And, again, the result would be that the exact sciences, which were drawn up concerning the motion and stopping and number and position and order of the works of God, would be set at naught.

Then, since we see that the exact sciences exist, and that everything else occurs definitely in its own season, regularly and without confusion according to one order, from this we know that He who created the world still orders and governs it.

* * *

The four elements, and their positions as the Creator ordained them.

2. TERRA EST IN MEDIO MUNDI, ET CETERA.¹

The earth is a round point in the very middle of the universe, fashioned as a perfect sphere with no substance beneath to support it and the water, as is natural, around it on every side, and, moreover, the Creator created the upper part of the earth as a dwelling place for men and for the animals that cannot live under water. And air surrounds both. And fire surrounds the three of them, and the firmament is on all sides around those four.

The following is a description of those four elements: -

Description of fire - A warm, dry, burning, light, liquid, movable body, beneath which is the air.

Description of air - A warm, wet, liquid, movable body, heavy in comparison with fire, and light in comparison with water.

Description of water - A cold, wet, liquid, movable body, beneath which is the earth, heavy in comparison with air and light in comparison with the earth.

Description of earth - A cold, dry, heavy immovable body that is beneath the whole of creation, and thus the earth comes before the water and the water before the air and the air before the fire and the fire before the firmament, because the firmament is the outermost of them, as this figure below shows.

¹ This Chapter is pretty close to Chapter 2 in Stabius' edition of the Latin. Originally from Aristotle's *Meteorologica* and *De Caelo*; principally the former. (Close)

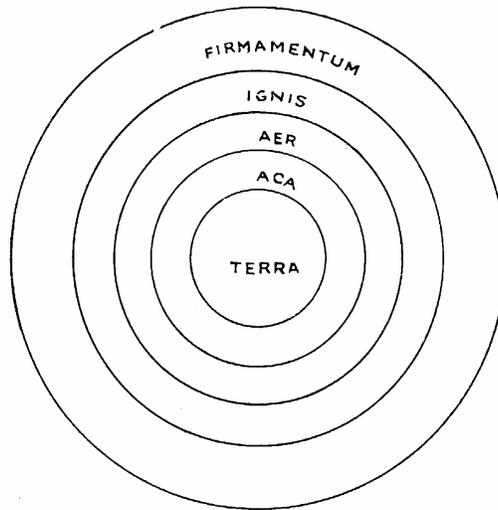


Figure 1

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3. DICUNT PHILOSOPHI, ET CETERA. ¹

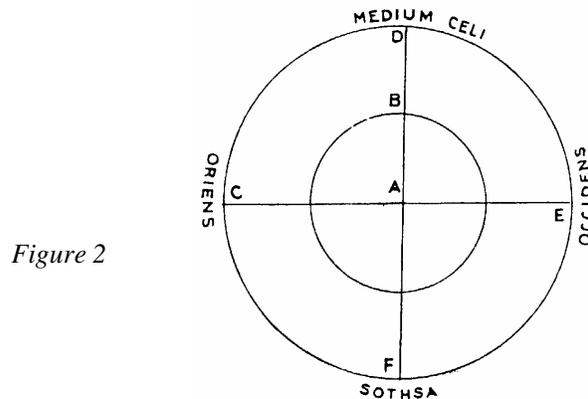
The philosophers declare that there are three motions, i.e., the motion from the centre, the motion towards the centre, and the motion around the centre.

Motion from the centre is the motion that proceeds equally out from the earth to every portion of the surrounding circle. Motion to the centre is the motion that proceeds downwards from the surrounding circle to the earth. Motion around the centre is the motion that revolves with the circle, and from its prime motions is produced every motion that is in the world, and one of these is the motion of the four elements, for some of them move from the centre, and some to the centre, and nothing moves around the centre naturally but the firmament or some portion of it.

Of the two elements that move to the centre, earth and water, the motion to the centre is swifter in earth than in water. Of the two elements that move from the centre, air and fire, fire moves more swiftly from the centre than air. And thus the elements that move to the centre are heavy, and the elements that move from the centre are light. From these facts let us conclude that earth is the heaviest element and fire the lightest. And although the water and the air are temperate between them, compared with each other and with the other elements, heaviness and lightness are found in them, for, although water is heavy compared to air, it is light compared to earth, and thus though air is light compared to water, it is heavy compared to fire.

¹ This Chapter is moderately close to Stabius' Chapter 5; but with the addition of the demonstration of the diagram. From Aristotle's *Meteorologica* and *De Caelo*; especially the former. (Close)

In order to demonstrate this subject more clearly I shall make a figure here below that will elucidate the meaning, of these words. First I shall make a figure of the earth and write A in the middle of it and I shall put the letter B at the top of it, and then I shall make the circle of the firmament around the earth and put C on the east side of it, and D on the top of it, and E on the west of it, and F on the lower part of it, and on the model of the figure there are two of the elemental bodies moving from the centre to the surrounding circle from A to B and these are fire and air.



There are also the two other bodies which move from the surrounding circle to the centre, i.e., from B to A, and these are earth and water. The third prime motion that exists, i.e., the motion around the surrounding circle, which is the motion of the firmament, moves thus, from C to D and from D to E and from E to F and from F to C, and that is sufficient for the experienced.

* * *

4. CALOR ET FRIGIDITAS, ET CETERA.¹

Heat and cold, wetness and dryness, are the four principal properties of the four elements, and they are accidents inseparable from them, and two of these properties are active, i.e., heat and cold. The reason why they are designated active qualities is that when we touch them, they make known to us then immediately at that very moment their own essence, for when we touch fire, it makes known to us then the essence of its heat. So, when we touch hoar frost it makes known to us then immediately at that same moment the essence of its coldness. The reason why we feel those immoderate things is that we have a moderate nature.

The remaining two properties are passive, and the reason why they are designated passive qualities here is because they do not make known their powers when touched, for when we touch a wet object or a dry object we do not feel its wetness or its dryness suddenly as we feel the heat of the fire or the

¹ This Chapter is moderately close to Chapter 4 in Stabius' edition of the Latin. Taken from Aristotle's *Meteorologica* and *De Caelo*; especially the former. (Close)

cold of the hoarfrost. That is why some of those properties are said to be active and some passive. Every body from the sphere of fire downwards is compounded of these (qualities) and they themselves (the bodies) are simple, even though they are said to be compounded of their own properties as hot, dry fire is a compound of those two properties [*i.e.*, of heat and dryness], since it is those two properties that preponderate in fire. And air is a compound of dryness and dampness, because it is they that preponderate in it and thus is the preponderance of the other two elements with regard to their own properties.

Although these four elements are compounded of the principal properties, they are termed simple in comparison with the elemental bodies that are compounded of themselves. Thus these four are both compound and simple. Simple compared to every object that is compounded of themselves. Compound compared to the prime qualities which are essential. Thus it is fitting for a simple body to have a simple motion, and for a compound body to have a compound motion.

And it is clear, that every body in which heat preponderates, moves from the centre upwards; and every body in which cold preponderates, moves in the direction of the centre. It is the heat that causes lightness in the natural bodies and it is the cold that causes heaviness and it is the dryness that causes rapidity of movement towards their natural place in light bodies. In the same way dampness causes slowness of motion in the bodies in which it is. From these statements we conclude that it is the nature of every one of those elements to remain in its own natural position in which is the end of its own motion, because if one of those elements were displaced by force from its own natural position, the nature of it would draw it again to the same position.

* * *

5. TERRA EST IN MEDIO, ET CETERA. ¹

The earth is in the very middle of the firmament as the centre for the descent of heavy bodies, *i.e.*, a middle point in a round thing.

As I mentioned, the natural position of the water is around the earth, and if it got space without obstruction from the earth, since it is a heavy, liquid, movable body, it would not stop until it would reach the centre of the earth, and it would remain there, because that, as we mentioned, is the last point of the motion of heavy bodies. And the parts of the water are pressing against each other, seeking the centre of the universe as a natural position for themselves if the firmness of the earth permitted them. Since the earth is round and firm, contending with the water, preventing it going to the centre, the water must be spherical around the earth, thus the other two elements that move upwards from the centre to the surrounding circle have a round shape.

¹ “This is like a rather free paraphrase of Chapter 5, in Stabius’ edition of the Latin.” (Close)

For fire, on account of its lightness, keeps drawing upwards until the firm indestructible sphere of the moon meets it, and since it cannot pass it, it keeps and covers itself under the round axle of that sphere, therefore it must itself be round as is the sphere of the moon that envelopes it (the fire) inside in itself. That sphere is the last course of the motion of light bodies. What makes the air spherical is that it has the surface of the spherical water forced up into its lower boundary and the upper part of the air itself is in the lower boundary of the fire, and since the fire and the water are spherical according to my proof, the air which is enclosed by them must be spherical in accordance with the shape of them.

Such is the position of those very close elements at each other's boundary, that nothing else can be between them, therefore there can be no vacuum in the whole of creation.

* * *

6. NOTUM EST UNUM QUODQUE ELEMENTORUM, ET CETERA. ¹

It is clear that each of the four elements are opposed to each other in their natures, their positions and their motions, for of all things that move from the centre, fire is swiftest, and likewise, of all the things that move to the centre, earth is swiftest; thus, earth and fire are opposed to each other on account of the heating properties of fire producing lightness in it, and on account of the cold properties of earth producing heaviness in it. Observe, when we say that earth and fire, or two other elements, are opposed to each other, that it is the properties of the elements that are understood then to be opposed to each other and not their substances, for the philosopher says in the "Liber Praedicamentorum," "*Substanti nihil est contrarium,*" - the substance has nothing of contrariety.

Thus when we say that fire is hot and dry, and earth cold and dry, the heat and cold of those two elements are opposed to each other; while they are in agreement with each other, inasmuch as the dryness effects speed in them.

Thus air and water agree with each other and are opposed to each other. They agree in the passive properties, *i.e.*, the dampness that is the cause of slowness in both. They are opposite in the active properties, *i.e.*, the heat which is the cause of lightness in air and coldness which is the cause of heaviness in water. Thus fire and water are opposite to each other in their active and passive qualities, since fire is warm, dry, swift and light, and water is cold, wet, slow and heavy. Finally, it is clear that things which have a direct motion remain in their own natural places, provided they are not forced out of them.

When one element is changed into another by the force of the second element, or when one element is displaced by force from its own natural position, as

¹ "This Chapter is not very close to Stabius' Chapter 6. It should have come immediately after the last chapter but one, *Calor et Frigiditas*. It is from Aristotle's *Meteorologica* and *De Caelo*; especially the former." (Close)

soon as it gets an opportunity or a little help, or when there is no opposition to it, it returns quickly and suddenly to its own nature and its own natural position.

Again, it is clear that everything that moves from the centre is hot and everything that moves to the centre is cold, and that everything that accelerates the motion is unquestionably dry and that everything that retards the motion is unquestionably wet.

Thus the Blessed Creator¹ created and arranged the world with its four elements.

* * *

7. ARGUMENTUM AD ROTUNDITATEM TERRAE, ET CETERA.²

It is a certain indisputable argument to prove the roundness of the earth, that the rivers run and flow over the surface of the earth. Because if the earth were a flat level surface with no convexity on it, as ignorant men have declared, the rain, which comes from the clouds and which is the cause of rivers, would form one large permanent expanse of sea on the surface of the earth, and would not flow from place to place as it does in now. Therefore, since it flows and does not remain in one place, let it be understood for certain that the earth is round and convex.³

Another argument to prove the same thing: - If you journeyed from the centre of the world to the North Sea, there would there be discovered to you stars that you never saw in the centre of the world, and some of the Southern stars that you saw in the centre of the world would be concealed from you. So if you made the same journey to the South, there would be discovered to you stars you did not see in the North or centre of the world, and the stars that you saw in these places would be concealed from you. Thus it is certain that it is the convexity of the earth, rising behind you on your journey, that discovers to you the stars before you, and conceals from you the stars behind you.

More on the same subject:-In every place you are throughout the earth, you see some portion of the firmament you did not see anywhere else, and it is proved from that, that the curve around the earth is spherical, and therefore the earth is in the middle of it. Of the same subject still, I add that, on every course which the sun makes around the earth, it illumines the half of the earth, that is exactly opposite it, and it is that light between the sun and the earth

¹ “ ‘Blessed Creator’ - In Stabius thus: ‘Creator, cuius nomina sanctificantur.’ The Moslems say that there are 99 names of God; The Jews reckon 72. Was it the Latin or the Irish translator who omitted the orientalism in this place? The Latin one as we know, being not Gerard of Sabbionetta.” (Close)

² This Chapter is not in Stabius’ edition of the Latin. It mentions spectacles, which were first used by the public about AD 1320.

³ “Observe this astonishing piece of absurdity. It was probably inserted by some ignorant transcriber. This subject is properly treated in Chapter 35, which is non-Messahalic, like the present one.” (Close)

which is always day; and [I say] that the other half of the earth is always dark, owing to the shadow of the earth, and it is that dark shadow which is always night. Thus whatever course the sun makes around the earth, day follows it and night flees before it to the other side of the earth. Hence, the people over whom the sun passes, see sun and day, and they who are at the other side of the earth see stars and night, therefore those things can never be seen during the same course, *i.e.*, sun and stars, night and day, because when we have day on the upper part of the globe there is night in the part beneath, and *vice versa*.¹ Consider carefully the expression which I used – ‘beneath the earth’. For everything that is down underneath the earth, is the earth or one of its parts, and everything that is on every side of the earth, out from the earth, is above. Therefore the earth alone with its parts is below and all the rest of the works of God, on whatever side of the earth they are, are above. Thus on whatever point of the globe people stand, their heads are up and their feet down. Whoever may declare that the earth is a level plane without convexity, whilst sun rises on one side of it and goes down on the other, I say that that cannot possibly be true, and that no reason or argument can be found to prove it; because if this theory were true, the sun would appear small when rising, and according as it mounted higher and approached nearer to us, it would appear larger to us. It is clear to every intelligent person in the world that this is untrue, since we see that it [the sun] is of equal size in the east and west and north of the world.

From this it is proved that the earth, and the course of the sun around the earth, are spherical, and to make this more clearly understood, I shall make a geometrical figure here below, and first I shall make the round figure of the circle of the globe, and write E in the middle of it - in the centre of it, and around that I shall describe a larger circle than that representing the orbit of the sun and place A in the west and B in the top and C in the east of it, and I shall describe a small circle representing the circular body of the sun, beside each of those letters, and then I shall draw three lines from the centre of the earth to the surrounding circle of the sun, one of those lines to A, the second to B, and the third to C. And it is evident to everyone who considers them that those three lines are even - equal each to each. Therefore the earth is equidistant from each, wherever the sun is, at its rising or setting, or when it is at the highest point of its course, and thus it is evident that the earth, and the circuit of the sun around the earth, are equidistant.

¹ “Probably there is some corruption of the text here; whether of the Latin; or the Irish.”
(Close)

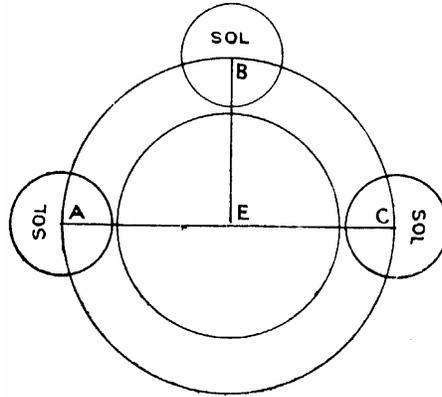


Figure 3

Whoever should declare as an argument against this that the sun appears distinctly larger¹ when rising or setting than it does at the highest point at mid-day, and that it is understood from this that it is further away at mid-day, than when it is in those other quarters, and that this proves that the earth is a level plane without convexity, I reply [to him] appropriately, in giving a solution for that argument, that that often happens, but not always, and when it does happen the reason is - when the sun is rising or setting, it draws up the moisture and the rain and black wet vapours rise to a great height between us and it, and then, when we look at the sun, that mist which is seen broadens and amplifies the sphere of vision within it², therefore, according to the denseness and materiality of that mist, does the sun appear larger through it, than it would appear without that mist being present. As the day advances, and the sun is at the highest point of the firmament with no mist between us and it, then we see it with its own proper size.

The example is clearly, illustrated in the case of the naked person under water, because he appears larger to the sight under water than out of water; although there is no proof in that, except the fact of the wet dense water spreading and amplifying the sight, and preventing it from passing directly and naturally towards the person. The same reason is the cause of an object appearing larger and thicker through glass than otherwise. Consequently old people, who are losing their sight so that they cannot read small letters, use glass spectacles³ to magnify the letters they read, and for the same reason the sun appears larger in the early morning and in the evening than at mid-day, as I have mentioned.

If any ignorant person should make the same statement, *i.e.*, that the earth is a level plane and the sun a round orb encircling the earth, and that the people of the world in general can see it at the same time as it would rise in one place, I should say that that was false, if it were stated. To understand it, imagine two cities in your own mind, one in the east and the other in the west of the world,

¹ "This phenomenon was observed and discussed at a very early date." (Close).

² "Poseidonius thought this, and many others." (Close)

³ "The mention of spectacles in this Chapter, which is not Messahalal's, may or may not prove that it is later than AD 1320; as it may have been inserted by some transcriber, whether Latin or Irish, after that date; though this is not likely." (Close)

and imagine if the earth were a level plane without convexity (as this opinion has hitherto maintained), that the people of the city in the east of the world would see the sun rise in their own proximity as a large mass, and, having traversed its circuit, they would see it setting in the west as a smaller mass. Vice versa, the people of the city in the west of the world would see the sun rise as a small mass, on account of its being distant from them, and set close to them, as a much larger mass on account of its proximity to them. *But we have never heard of any such thing. In addition to this we may point out*¹, the first half of the day would seem shorter to the people of the eastern city than the latter half. In the same manner the latter half of the day would seem shorter to the people of the western city than the first half.

We, and the learned, have an unquestionable proof that the day is of equal length at equal distances from the middle point of the day at those two cities, and in every place in the world, and that it is error and lack of knowledge which caused the other opinion to be upheld. It is clearly proved from that equality of the first and last half of the day that the sun moves in a circular orbit² about the spherical earth³.

To further illustrate this subject, and to confute that theory, I will make a geometrical figure here below.

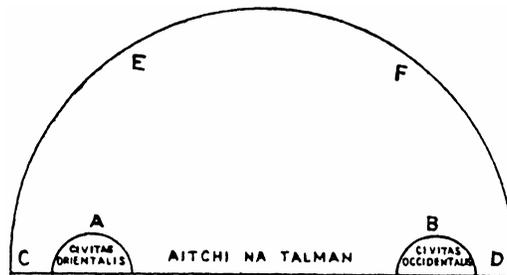


Figure 4

First I will draw a straight line called the surface of the earth, and above it a circle, which I will call the path of the course of the sun, and I will make a diagram of a city on the eastern end of the line and write the letter A above it, and in the western end of the same line I will make a diagram of another city and write B above it, and C at the point of the rising of the sun, and D at the point of its setting, and E at mid-day of the eastern city, and F at mid-day of the western. Consequently when the sun rises at a point C, and advances to E, the first half of the day in the eastern city is spent, and the second stage, from E to D has not arrived, and again when the sun rises at a point C and advances to F, the first half of the day in the western city is spent and the second stage from F to D has not arrived, accordingly day at each of those cities would have one part longer than the other, because it is much longer from E to D, the

¹ “(At this point) something to this effect seems to have dropped out of transcription and requires to be supplied.” (Close).

I have included this addition of Close in italics. (JW)

² *Sibal a cercaill cruinn*

³ *Talman cruinne.*

last part of the day in the eastern city, than from C to E, the first part of the day in the same city. Again, it is much longer from C to F, the first part of the day in the western city, than from F to D, the last part of the same day. And it is evident to everyone on earth who wishes to examine it closely that that is untrue, therefore the statements out of which it arises are erroneous, i.e., that the earth is a level plane without convexity, and therefore, in the interests of truth, it is declared that the earth is convex and spherical.

As a proof that it is true, the sun does not set in the same place in regard to any two cities in world, and, if you change your position, you change the sunset in regard to you. As a proof of that: - If you were in the city of Jerusalem, in regard to you, the sun would set in Rome, and if you were there, it would set in the west of France, in regard to you, and on your being there, it would set in the west of Spain in regard to you. After that some place in the Atlantic Ocean would conceal it from you, and if¹ sea could support you, and if you could follow the sun, it would change its setting in regard to you every day that you would follow it, until at last it would set in the place in which you saw it rising, when you were in the city of Jerusalem.²

It is certain there is no difference in the sunset, but the convexity of the earth constantly coming between us and it [causes it], because if the earth were a level plane according to that theory just mentioned, there would be only one place where the sun would rise in regard to the inhabitants of the world, and one place where it would set. Consequently since there are a number of places where it rises and sets, the earth must be round and not a level plane.

Therefore the Eternal First Cause who ordered it thus, blessed be He forever.³

* * *

8. MARIA ET FLUMINA DIVERSA LOCA MUTANT, ET CETERA.⁴

The sea and the rivers change in many places, but it is not evident that it happens until after many centuries. In this manner does that change come about: as the waters break the hills, the earth of the hills falls to the bottom of the waters, and fills up the place of the water, and since the waters are forced out of their own position, they must occupy some other place where they can get room. By reason of that the sea washes over and submerges cities, towns and districts in which are the abodes of men in valleys and low

¹ The conditional nature of this proposition places the Tract clearly in the pre-Columban era.

² This example is a graphic anticipation of the voyages of Columbus and subsequent navigators a century or so later.

³ "This concluding sentence seems to point to an Arabic original. Chapter 35 seems to be the now separated continuation of this Chapter 7. Both are non-Messahallic. Chapter 35 is from an Arabic original. Observe *al kotera*, (the diameter)." (Close)

⁴ "This Chapter is not in the Latin of Stabius. It may be suggested by Aristotle's *Meteorologica*. But perhaps it is more than suggested by Avicenna's *De Congelatione et Conglulatione Lapidum*, Cap II., *De Causa Montium*. This is printed along with Geber's *Summa Perfectionis Magisterii in sua Naturate*. Avicenna died in AD 1030." (Close)

places near the sea. The moisture¹ that comes from the clouds is the cause of this, because when it falls, it flows constantly about the earth rooting up the soil, and everything insoluble and non-resistant that it finds in the earth it carries from place to place in the rivers, and the force of the rivers carries off the same things to the sea, and the bottom of the sea is filled with them². On that account must the sea vacate that spot and seek some other. The hills break the place whither they go, and fill the valleys, therefore the dwelling places and domains of men change, i.e., cities, lands, hills and valleys.

For it is a natural thing for water, since it is fluid, not to be always in one place, but to travel from place to place. Consequently, the rivers carry the weakest soil with them to the sea, and from being a very long time there it becomes firm and hardens and becomes petrified,³ and from the constant beating of the waves beneath it and above it, the stones are carved and polished and assume different shapes. Some of them become round, some broad, some long and some short. Likewise the rivers bring, the sand and light stones to the sea, and they are gathered together by the beating to and fro of the waves outside, and after many hundreds of years it [i.e., the new earth, formed as described] mounts and rises up over the sea, and hills and mountains are formed from it,⁴ and the sea sends some of it towards other lands, and that is the material from which cities and lands are formed.

As a proof that it is true, there are to be seen in many places that have been submerged, stone houses, castles, churches and carved stones and planks, and many unquestionable signs from which it is proved that human habitations were some time in those places.

Another fact to prove the same thing; there will be found plainly in the summits of the hills and mountains, the paths and roads of the sea, which resembles the ridges and the small irregular furrows that are seen in the mud of the sea when the tide has ebbed. Also there are found many shells and small sea fish in the same places which have become hard, firm and petrified.⁵ In the same manner the rain forms the mountains and valleys of the world, because, when the rain flows into a place where it finds the soil weak, it turns it up and forms a furrow in it, and the edge of the furrow, on either side falls, both sand and soil, into the channel by the strength of the water and the water brings that with it to the rivers, and the rivers carry it to the sea, and from the excess of rain over a very long period ever falling into those furrows and constantly carrying away the soil and sand, those furrows become valleys of the sea, and at last the earth is left in hills and large mountains between them; and thus did the blessed Creator of the world order that.

¹ Lit. 'sea'.

² The Irish author is clearly groping for terms such as 'weathering', 'erosion', 'deposition' and 'sedimentation'; terms whose concepts were not clarified for centuries to come.

³ "See Avicenna, *ut supra*." (Close).

⁴ "See Avicenna, *ut supra*." (Close).

⁵ A suitable word for 'fossil' was clearly missing in Irish. It had long been suspected that fossils had an organic origin. C.f. Herodotus, 5th cent BC. (JW)

"Fossil organic remains. Avicenna, *ut supra*," (Close)

9. CALOR ET FRIGUS OPUS VEHEMENS IN TERRAM, ETCETERA.¹

Intense and swift are the actions that cold and heat perform in the earth. For in summer the heat of the sun warms the surface of the earth, and since two contrary things do not endure to remain in the same place, the cold flies before the heat to the bowels of the earth and that makes the water which it finds under the earth cold, and on that account the water of the wells is cold in summer. For the same reason, on account of the (great) distance of the sun from us in winter,² the cold gains strength then on the surface of this whole earth, and sends the heat flying in before it to the interior of the earth. Therefore the water of the wells is warm in winter; and when, in the summer, that cold is in the middle of the earth in all its strength, it concentrates and compresses itself there, since the solidity and firmness of the earth does not allow it to escape, and the further in it is, the greater is its power and strength. In the winter when the cold of the earth's surface sends the heat into the centre of the earth, and finds the prisoner inside before it, i.e., the cold of the centre of the earth, they act upon each other, and each of them seeks to destroy the other, and the earth shakes; and it is to that shaking that *terrae motus*, i.e., earthquake³, is applied. It results from that shock that the earth is cut and broken and great wind accompanied by thunder and noise comes forth from that breach, and the wind carries with it sods of earth and stones, and no person, animal, castle, or any other solid thing that one of those stones would strike, could escape its passing through them.

It often happens at a time of *terrae motus* that the sun is darkened; and the cause of that darkness is that the strong wind, that comes from that rupture of the earth, blows much dust and sods with strength and force from it up into the air. And that dust is like a cloud between the earth and the sun, and cuts off the light of the sun from the surrounding nations.

At another time the *terrae motus* breaks the earth under the sea, and the wind that comes out of the water blows up into the air and makes the sea rage in a terrible manner.⁴ The same shock tears hills and mountains when there is a disturbance beneath them, so that it leaves deep dark crevices which appear bottomless.

Moreover, waters taste differently according as they are situated in different places. Although all waters have the same substance, they adopt an accidental peculiarity according to the taste of the earth in which they are situated. Consequently, the water that is in a stony, sandy place has a sweet taste, and the water that is in salt earth has a salty taste, and the water that is in clay soil has a flat taste, and the water that is in acid earth, where there are stones of

¹ "This chapter is not in the Latin of Stabius. It is probably suggested by Aristotle's *Meteorologica, Lib. I.*"(Close)

² " 'distance of the sun in winter'. This merely means that the sun has left our northern latitudes, to be over southern ones. It does not refer to the distance of the sun from the earth in its annual revolution around the earth." (Close)

³ Lit., 'trembling of the earth', *crit na talman*.

⁴ The term, "tsunami wave", had to wait many centuries!

sulfur or alum, or a place where there is a brass or copper mine or other acids, that water has a bitter taste; therefore, in accordance with the accidental peculiarity of the taste of the soil in which the waters are, does the water change the accident of taste.

Also, when the rivers that flow on the surface of the earth encounter weak, movable soil they pierce through it and make secret paths for themselves in it beneath the earth, until they meet immovable earth that does not let them pass to this side or that. Since, when, they thus come in conflict below, the earth breaks overhead, and they are converted into wells, according to the greatness or smallness of the underground streams whence they come, or according to the quantity of the rain, from whence the streams come, since it is in accordance with that that the wells fill or dry up.

The cause of the saltiness of the sea is its own antiquity and the constant beating of the waves around its stones, and the course of the sun being always above it, and because the sweetest parts of the water are driven from it by the heat of the sun.¹ For the heat of the sun draws the most volatile and sweetest part of the water of the sea up into the clouds of the air, and from that are made the dew and the rain and the snow and the hailstones and every other phenomenon from above. It leaves below the heaviest, most solid, most material, and sourest portion. From its similar nature, human urine is sour, for the same action as is performed by the sun upon the sea, is performed by the bile² upon the urine, as it filters it and extracts the volatile parts from it.

From the same cause water that receives much boiling becomes bitter, as the heat of the fire vapourises it. When that salt seawater receives much boiling on the fire, or from the sun in warm countries, it becomes crystallised³ and solidified, and adopts the nature of the earth, and that is the salt we use. That effect is produced by the excessive boiling, caused by fire or by the sun vapourising them [i.e., the waters]. They are thus strained, and become solid and converted into the nature of the earth in accordance with (their) solidity. And sometimes fresh water, and particularly the water of rivers, is bound by the intensity of the cold and converted into ice. The natural heat that is in the sea, and the fact that it is still, does not permit it to take that binding upon itself from the cold, because it is the nature of cold to bind everything that flows and the nature of heat to dissolve every bound thing, as the philosophers say.

* * *

¹ “c.f., Aristotle’s *Meteorologica*, Lib.II”. (Close)

² Ir.; *lionn ruad* –lit. ‘red humour’

³ Lit. ‘calcified’. The reference is to the crystallised salt residue remaining after the evaporation of the sea water.

Concerning the two volcanoes, Etna in Sicily and Vesuvius in Apulia, in the sulfurous region.

10. DICO QUOD OCCASIO HUIUS IGNIS EST, ETCETERA.¹

I declare that it is the amount of the sulfur which is the cause of the fire that is constantly burning, and this is how it is: When the fire begins, to perform an action in the veins of sulfur beneath the earth it continues always to burn the sulfur and the earth before it, so that it cannot be extinguished.

Consequently it makes holes and crevices before it in the earth, and when the sulfur that is naturally in it comes to the end, it grows again. When it grows, it turns again and burns it again, and that growth of the sulfur and the burning of the fire are ever increasing, and the flame as it rises from it, throws up many balls and masses of fire which come forth from the substance of the sulfur, and they collect in one direction and mountains are formed from them.

There is often heard a great, terrible sound from the wind going into those hollows and blowing with the flame as it comes out. The waters that are generated from these fiery places are hot, for as I have mentioned, the waters receive [their] accident from the place whence they come.²

* * *

¹ “This Chapter is not in the Latin of Stabius. *Huius ignis* evidently refers to something going immediately before in the work from which this chapter has been borrowed. It is quite inappropriate as it stands here.” (Close)

² The author is following a traditional interpretation that dates back to Classical times. An earlier Irish scholar, Dicuil, writing on the Continent (c.820) addresses the same question in the case of Mt Etna. Basing his remarks on earlier works by *Iulius Solinus* and *Servius*, he states that, “it is well known that Etna . . . has caves full of sulfur that reaches down to the sea. These caves receive the waves and create a blast of wind, whose violence fires the sulfur, which causes the fire which is visible”.

C. Iulius Solinus, *Collectanea Reum Memorabilium*, ed. Th. Mommsen, Berolini, 1895.
Seruius, *Commentarius in Aeneidem*, ed. G. Thilo, Lipsiae, 1923. (JW)

11. LUNA VISIBILITER IN MARE, ETCETERA.¹

The moon acts visibly on the sea and on the other moist things, for the philosophers say that the sea never ceases flowing from the time the moon is in the east of its circuit until the time it is at the topmost part of the circuit, and that it does not cease then constantly ebbing until it is setting in the westerly point of its circuit, and that it does not cease then constantly flowing until the moon is in the middle point of its circuit beneath the earth; and from that again that it does not cease constantly ebbing until it is in the easterly point of its circuit, and then it begins again flowing as it did before.

Thus, according to the rising and setting of the moon, the sea never ceases flowing and ebbing, and when the moon is in the same degree as the sun, then its light is greatest and strongest, i.e., at the beginning, of each month, and it is then the ebb and flow of the tide are greatest.² In the second course [of the moon] the ebb and flow of the tide are greatest in the middle of every month, when the moon has its full light,³ facing us, for it is then the light of the sun is reflected down from the moon towards the sea and brings about the ebb and flow of the tide.⁴

Thus, too, the moon reveals the same acts in the marrow, brain, and blood of men, because those three things are increased and decreased in the beginning and middle of every month according to the course of the moon. And, accordingly, diseases caused by bad blood, such as boils and many other things, do not occur except at the beginning and middle of every month.

The actions of the moon are evident again in accordance with increase and decrease, in the cucumbers and gourds and in every thing in which moisture preponderates, according to the course of the moon. The natural cause of that is that the moon controls moist things and particularly the water of the sea, as lodestone does iron⁵, for as lodestone attracts the iron to itself, in the same way the moon attracts the water of the sea, and that is termed the flow of the

¹ "This Chapter is not in the Latin of Stabius." (Close)

² I.e., when the moon is in line with the earth and sun. The resulting 'king tide' accompanies the full moon, but not for the reason given in this paragraph. C.f footnote 4 of Maxwell Close.

³ "It is here supposed that the light of the moon is, at least (in part), concerned in the production of tides. Averroes thought this." (Close)

⁴ "This on the Tides is very close to what we have on the subject in Strabo, *Geogr.*, III, V, 8-9, and in Pliny, *Nat. Hist.*, II, 99 (97); especially the former. Pliny was well known and used in the Middle Ages. Strabo follows Poseidonius in the Tides." (Close)

⁵ "Here a quite different cause is given for the Tides, the magnet-like attraction of the moon on the water. This is also given by the Jesuits of the College at Coimbra. See *Commentarii Collegii Conimbricensis in Aristot. Meteor.* Tractus VIII, *De Mari*, Cap VI, p87 (Colonia, 1596). Compare Kepler's *Mysterium Cosmographicum*, also 1596. He, however, would not limit the attractive power of the moon to moist substances and the waters of the sea. - - - But we find they were themselves anticipated, on this matter, in our Irish ms., which was written about 200 years before their Commentary." C.f., Close, M H, *Remarks on a Cosmographical Tractate in the Irish Language*, Proceedings of the Royal Irish Academy, (1900-02) p457-464." (Close)

This is a remarkably appropriate analogy for the action of gravitational forces at play in the earth's tidal movements, bearing in mind the fact that the concept of gravitational force was not clarified until the time of Newton. (JW)

tide. When, that attraction ceases, the tide turns back to its own position, and that is termed ebb.

This ebb and flow are more visible in the east and west of the world than in the Red Sea or in the African Sea¹ or in the other seas that come from the Great Ocean, for some of these have a straight course directly west, in others the tide flows directly east through the power of the operation of the moon above them, consequently that flow or ebb is not evident on the shores of the sea in those places.

To explain those operations of the moon as regards the ebb and flow of the tide, I will make a geometrical figure here below:

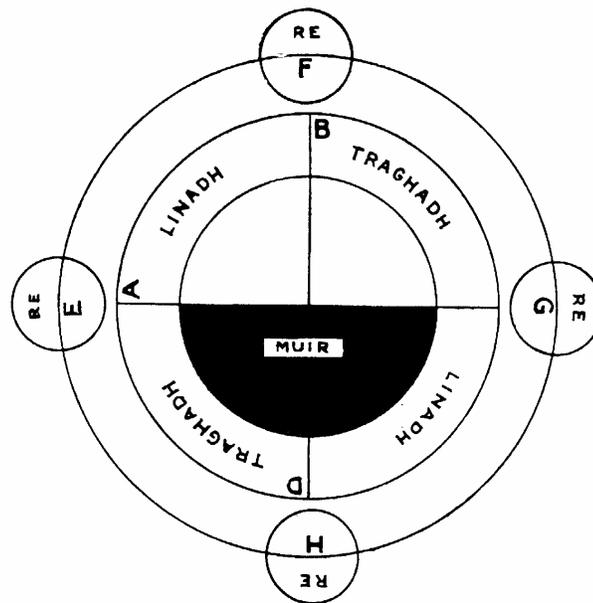


Figure 5

Firstly, I will make the round figure of the earth and divide it into four equal parts, and write these four letters in their respective places around these four divisions, i.e., A. B, C, D. And around the earth I will describe the figure of the sphere of the moon, and place E in the east of it and F in the centre of the top and G in the west and H in the centre of the lower part, and I will darken half of the globe to represent the sea and leave the other half dry and white. Thus when the moon is in the east of its own circle at a point E exactly opposite A, the tide then begins to fill and does not cease constantly filling until the moon reaches point F that is opposite D, and then the tide begins to ebb and does not cease constantly, ebbing until the moon reaches point G which is opposite C. It is ever filling until the moon reaches point H opposite D, and it is ever again ebbing, until the moon arrives opposite A.

* * *

¹ Presumably the Mediterranean, if we accept that Africa refers to the region of North Africa around Carthage in which case the tidal movements are minimal. The 'Great Ocean' most likely refers to the Indian Ocean. (JW)

12. SOLENT QUIDAM IMPERIT ASSERERE, ETCETERA.¹

Some of the ignorant declare that the flood of the river Nile is caused by the great rains that fall in distant lands, and as the river fills, it bursts forth throughout the land of Egypt, and what rain does for the other races, the water of the river Nile does for the Egyptians. I declare that they have no argument or reason to prove that statement, except one single theory, because, as they see the other rivers of the world becoming swollen by rains, they think that the river Nile is thus swollen.

I will now prove that that theory is false, because if the rains were the cause of the flooding of the river Nile, as they declared, it would become swollen, with no special period for its filling, every time it should rain heavily throughout the year as the other rivers become swollen. It is clear to everyone who sees it that that river does not become swollen except at a particular time of the year, i.e., in the month of August; but when there is a plentiful fall of rain in some district near Egypt that river becomes slightly swollen on account of that rain, because rain that falls in districts distant from Egypt never increases the river Nile on account of the great distance of the source of the river from Egypt, and of the exceeding dryness of the soil. Consequently, at whatever period of spring or summer or any other season rain falls, the sandy, very dry soil and the parching of the sun absorbs the rain water, and does not allow it advance to the river; or, when the river is swollen from excessive rain together with the great sudden floods, the heat of the earth around the river is so great, that no sooner are the floods at their full, than the earth absorbs them. The water in that river is seldom accidental, and it is always filled bank to bank with its own water.

As a proof of that: if you made a trench two or three hundred miles long through the dry earth, although you might pour a great amount of water into one end of it, the earth would absorb it all before one drop would reach the other end of it; thus does the parched, hot soil of the river Nile absorb the waters that fall around it before they reach Egypt; consequently rain is not the cause of the flooding of the river Nile.

Another fact to prove the same thing as I heard from my own elders²: the Egyptians thought at one period that the river Nile would not rise until the fairest maiden of greatest beauty in Egypt should be cast into it, and because they were obliged to get the overflow of the river to moisten the earth, since that is what they have instead of rain, they used to cast the most beautiful maiden that could be found in the whole land into the river in the beginning of the month of August, and the hour after that the river used to be filled, not on account of the woman being cast into it but because its own time had come, and it used to fill all Egypt around it. And this kind [of evil practice] was in vogue in Egypt until the time of Omar, King of Egypt. As he saw her die by

¹ This Chapter is not in the Latin of Stabius.

²: "The nearest account that I have found to the story, as given here, of the maiden sacrificed to the Nile is in Murtadi, *The Egyptian History, according to the opinions and traditions of the Arabians*. Translated into French by Vattier, and thence into English by Davies. London, 1672. See pp. 142-145 of that book." (Close)

that rude, sinful, evil custom in the beginning of the month of August, he composed a short letter¹, and said in it, “In the name of the merciful Lord, Thomarus,² King of Egypt; Life and health to the river Nile, and if it be thy will O River Nile, through the powers of God to pour thy water on the land of Egypt, we pray thee do so now; and if it be not thy will, we have no reliance in thee.”

He put the letter then into the river, yet not on account of the letter nor on account of the woman, but because its own time had come, it overflowed its banks mightily and filled Egypt. Consequently, if that flood resulted from those rains, since rain falls frequently during the year, the river would become swollen frequently. Thus as that theory is false, I shall disclose the true cause of the flood of the river Nile.

I declare that the source of the river is between the east of the world and the southern quarter; between the west of the world and the northern quarter, it enters the sea. The atmosphere of Egypt is warm and dry, so that it but seldom admits wind or clouds or rain to exist in it. For although the surrounding countries experience wind, that air condenses and contracts, so that it is accompanied by a very great storm that clouds or rain enter the boundary of that air, and when it enters - which is seldom - there is terrible thunder and very great wind and lightning, which kills the flocks of Egypt. It is the nature of air in general to spread and expand, when it becomes warm; and when it grows cold to press together, and it contracts and draws towards it everything like unto it. The sea air is colder in the night than in the day, consequently, when the sun reaches its mid-day position, through the heat of the sun the air spreads and expands and the wind blows from that time until midnight into the mouths of the rivers which flow westwards into the sea, and (the wind) opposes the rivers, and drives them forcibly back, and does not permit them to flow into the sea until the cold of the night lessens the strength of the heat of the sun; and, consequently, the conflict with the streams results from the heat of the atmosphere and the flowing into the sea from the coldness of the atmosphere. As the sea air is warmer in the day than in the night, and it is owing to the proximity of the sun to us and its distance from us that that change comes over the atmosphere; thus, at the time of the year the sun is nearest to us, i.e., the summer, the sea air is hottest. Consequently on the first day of the month of May until the sun enters the September equinox the sea-breeze blows eastwards towards Egypt over the river Nile, and joins with the air of Egypt to set it in motion and expel it from its own place. Since that air is dry, heavy, and difficult to move, it opposes the wind and does not abandon its own place, and since the wind that is always blowing finds no other course,

¹ “Murtadi gives the letter thus;

‘In the name of God gracious and merciful, God bless Mahumet and his family – From Gabdol Omar, son of Chettabus, Commander of the faithful, to the Nile of Egypt – If thou hast flowed hitherto by thine own virtue, flow no more; but if it has been the only and Almighty God that hath caused thee to flow, we pray the only great and Almighty God to make thee flow again. God’s peace and mercy be with Mahumet, the idiot – Prophet, and his family.’

They found next morning that God had caused the river to rise sixteen cubits.” (Close)

² “ ‘Thomarus’ – This is the only way that the Irish translator had of representing phonetically Homarus, the Latinised form of ‘Omar. Egypt was conquered by the Saracens under the Khalif ‘Omar. It is incredible that this practice could have lasted until the time of ‘Omar.’” (Close)

it turns the river Nile forcibly back, and does not allow a drop of it to enter the sea, and the same wind sweeps much of the sea sand forcibly into the mouth of the river Nile.

Consequently, since the river is prevented from flowing into the sea, it becomes flooded throughout Egypt, and that flood continues as long as the wind has its own force, i.e., during the time I have just mentioned, from the first day of May until the September equinox. Then the wind begins to lose its strength, and the sun leaves its position directly over the sea, and sinks by degrees in the southern quarter of the world. When the water of the river finds no opposition from the wind as it did up to this, it breaks the mountain of sand and proceeds on to the sea and departs from Egypt; and then the Egyptians plough and sow, since they are certain that the river will not hinder them until that season again. Consequently, it is evident that they would be often hindered earlier than that season if the flood of the river Nile resulted from rains.

The rivers of the other lands which flow into the Western sea experience the same flooding although it does not happen to them so much as it does to the river Nile, for there is only weak movable air, that does not contend with the wind, and moves in every direction in which it is carried into the other lands. On that account no other river in (other) countries is as wide as the river Nile at its flood; and may He who created the river Nile be blessed forever in *saecula saeculorum*.

* * *

13. DICO SICUT SUPERIUS VERACITER, ETCETERA. ¹

I declare truly, as I declared in the beginning, that light bodies are the bodies that move from the centre to the surrounding circle, and that heavy bodies are the bodies that move from that to the centre, and that the four elements and everything that is composed of them have these two direct motions. Consequently, since the firmament does not move from the centre, or to the centre,² let it be understood that it is neither heavy nor light; because if it were heavy, it would move to the centre; and if it were light, it would move from the centre, and since we understand it to be neither one nor the other, we must assume it to be neither hot nor cold, because it is in hot bodies like fire that lightness is, and since that is not light, as we proved, there cannot be heat in it; and since it is in heavy bodies like the earth cold is, since the firmament is not heavy, there cannot be cold in it. Let it be understood again from that that the firmament is neither wet nor dry, because wetness causes slowness in the body in which it is, as it does in air, which moves from the centre, and in water, which moves to the centre. Thus dryness effects velocity in the bodies in which it is, as it does in fire which moves from the centre, and in earth which moves to the centre. Since there is neither swiftness nor slowness in the

¹ “This Chapter is like a free paraphrase of the corresponding Chapter (7) in Stabius.” (Close)

² “c.f. Aristotle *De Caelo*, Book I”, (Close)

firmament, it is at no time swifter or slower than at another, since God created it, but it had, has, and will have one identical, steady, constant motion until the end of the world. Consequently there is no wetness nor dryness in it from which swiftness or slowness could result. Similarly, it is the same motion that the sphere of the constellations and the seven spheres of the seven planets have, had, and will have until the end of the world.

There are some ignorant men who are uninformed as regards the works of God, who say that the firmament was composed from the four elements, which is clearly contrary to truth, for since the four elements possess a nature different in everything from the nature of the firmament, reason can not admit that the firmament could be composed of these. Because, as I said before, it is the nature of the four elements, that some of them move towards the centre, and others out from the centre, and that that motion occurs at regular intervals, and is slower at the end than at the beginning, and that they (the elements) are permanent in their own places, and that they never leave those places except by force, for each of the four elements is equal to the other as regards length of existence and natural permanence.

Besides, the four elements possess various properties; heat and cold, wetness and dryness, lightness and heaviness, swiftness and slowness, and the nature of the firmament is directly opposed to those natures; because in opposition to the vertical motion of the four elements, there is the circular motion of the firmament, and in opposition to the periodical occurrence of that motion, is the perpetuity in the motion of the firmament, and in opposition to the swiftness and tardiness of that motion, is the perpetual slowness in the motion of the firmament. In opposition to that lasting permanency of the four elements, in their own positions, is the permanent natural motion of the firmament in its own position. And as the four elements and their state of permanency are of equal antiquity, in the same way, the firmament and its motion are of equal antiquity, and is without any of these properties of the four elements, for there is neither heat nor cold, wetness or dryness in it, nor lightness or heaviness, nor swiftness nor slowness.

As the parts of the four elements are made, they never become corrupted nor changed but (are) as they were from the beginning of the world, firm, compact, indestructible, indissoluble, and thus they will be until the end which the Creator ordered for them. Consequently, since the nature of the four elements and the nature of the firmament are directly opposed to each other, it is against reason to say that the firmament was composed of the four elements.

Another reason against the same theory: Every object that is compounded from contrary elements that work against each other and corrupting each other, the whole corrupts in the end; such includes mankind and animals, and everything else that is composed of the four elements in which the opposite properties of the four elements destroy each other. And when one property prevails over the other, the thing that is composed of them is completely destroyed. Consequently, if the firmament were composed of the four elements, owing to those opposite qualities being mutually destructive, in the end the firmament would be dissolved and would perish.

Thus since no sign of the dissolution is, has been, or will be, observed, let it be understood that it (the firmament) is far from being composed of the four elements. Thus may He who ordered it in such wise be blessed by everyone who would behold it.

* * *

14. QUANDO DEUS FIRMAMENTUM CREAUIT, ET CETERA. ¹

When God created the firmament He ordained a full perfect motion that never increases or decreases; since in twenty-four hours the firmament completes its course without fail and without deception, and those twenty-four hours are day and night.

God also made the sphere of the sun to manifest day and night; and their nature, their length, and shortness, and to manifest the regularity of the heavens, and the difference of increase and decrease of heat and cold in different places, in order to propagate creatures from each other, and to fulfil the order of the world, because if the firmament and the sun moved more quickly than they do, the days and nights would be shortened, the sun would not have time to fulfil its functions, and terrestrial creatures would refuse to grow; and if they moved more slowly than they do, night and day would be lengthened, and, consequently, as the sun would be too long over the earth, it would parch and dry up the surface of the earth, and would permit nothing to grow in the soil. Thus men could not dwell in the southern part of the world, as they do now at a distance of sixteen degrees from the equator because if the sun stayed too long, it would make that place uninhabitable.² Similarly, at about the end of sixty-six degrees³ of the firmament northwards from the same line, the region beneath them would be uninhabitable on account of the cold of the very long night. The region from the end of those sixty-six degrees is uninhabitable on account of excessive cold as far as the region that is under the sun's course. For the sun inclines towards the south side of the world, the cold increases so much on the north side, that animals cannot dwell in it and the trees do not grow. And so men or animals cannot dwell south of the aforementioned line on account of excessive heat, and in the land that is

¹ "This Chapter is not Messahallah's, not in Stabius. That it is not in Mesahalah's own, is specially evident from the following; It partly repeats some things going before in Chapters 1,3,4 & 6; and partly anticipates matter in Chapter 29 (all by Messahalah). It contains contradictions of certain of Messahallah's own statements, in other works of his, respecting the properties of the signs. Moreover, at the very end of the chapter, the writer promises to return to the subject there in hand; but this is not done in the present astronomical tract; doubtless it was done in the work from which this chapter is borrowed. The earlier part of this Chapter is, doubtless, whether mediately or immediately, from Aristotle." (Close)

² "This is inconsistent with chapter 36, where the First Habitable Climate is made to begin at the equator. That Chapter, like the present, is not by Messahalah. It is different also from the ordinary scheme of habitable climates, whose southern boundary is 12½°." (Close)

³ Slight discrepancies for these angles exist between the RIA and Marsh manuscripts. The Marsh figure is used here. It conforms with that of Alfergani. (JW)

nearest that line on the inside are the Negroes¹ who are darkened by the excessive heat of the sun.

I mentioned above that there are none of the opposite qualities in the firmament from which every corruption and dissolution results, and consequently they have no opposite motion, since the motion of every body in the universe must be circular or vertical or a compound of both as is the motion of a cart wheel. The circular and vertical motions are simple, consequently every body, simple or compound, moves in a circle or vertically. But circular motion is the motion that moves like a circle around a centre, and vertical motion is the motion that moves from a centre upwards [or] to a centre downwards, and the three motions are simple motions, and the circular motion is simpler than the other two motions, because the body that moves thus is simpler than any other body.

Those two motions that move to and from the centre are compound compared to the circular motion, and they, are simple compared to the motion of things that are composed of the four elements, because, in reality, there is no compound motion but that one, and though each of the four elemental bodies is composed of two qualities, they are simple compared to the bodies that are composed of them (the elements). Thus the circular motion, on account of its being naturally a perfect motion without beginning or end, its course does not permit of being stationary or of turning back. Not so is the vertical motion, which sometimes moves independently of the bodies, for when some element is outside of its own natural position, it moves suddenly back towards its own place and remains naturally there; thus that motion has beginning and end, and the thing that has a beginning and an end is imperfect; consequently the vertical motion is an imperfect motion. As every perfect thing is superior to, and greater, more permanent, and more noble than every imperfect thing, in the same way, circular motion in the same degrees surpasses vertical motion.

Additional proof of the same thing: the philosophers declare that the motion that is foreign to one thing is natural to another, for instance the upward motion of fire and of earth or the downward motion of both. As every non-essential thing is accidental, and every essential natural thing is a substance, and as the accident and the substance are opposite to each other, in the same way the non-essential motion and the natural motion are opposite to each other. Not only (that), but things that are below and above, right and left, before and behind, are contrary to one another. And as everything which has not contrariety is nobler than that which has, in the same way the circular motion which has no contrariety is superior to every other motion I have mentioned.

Additional proof of the same thing: everything that moves naturally with a vertical motion can be moved by force and contrary to nature, but such is not

¹ Ir., 'fir gorma', lit. 'blue men'. The more expected term, *fir dubh*, might have had other connotations; perhaps inferring hair colour rather than skin, or adverse character attributes. (JW)

"An illustration of the occasional veiguess on the use of the names of the colours in Irish; similar to what we have in Homer, for instance." (Close)

the case with the circular motion, for the spherical circular course which was ordered for it at the beginning of the world, it was, is, and forever will be preserving this without fail, and without moving to any one side of it. Consequently it is clear that the circular motion is superior to any other motion, and more constant.

Although each of the spheres of the firmament has a separate motion, they all move together without opposition; for, if there were contrariety in the firmament as there is in the elemental bodies, everything it effects in them would cause a similar effect in the firmament, and thus the strongest body in the firmament would change the weakest body into its own nature, and similarly we should see the planets, and constellations, and the other stars at one time larger, at another smaller than one another. This is not seen now, and was not, and never will be seen. Thus it is clear whence those changes, *i.e.*, the contrariety in the firmament can be understood.

Thus is the great smooth, firm body in the firmament - a round sphere like a ball, around its own centre, its centre in a middle point, which remains for ever in one point, and ever moving and it is certain that the motion is uniform since it has never made the least halt, and does not move swifter or slower at one time more than another, and thus are the seven spheres of the seven planets: - the moon, Mercury, Venus, the sun, Mars, Jupiter, Saturn, and the sphere of the fixed stars and the sphere of the twelve signs,¹ *i.e.*, the sphere which we call the firmament.² Thus were those ten spheres since the time God created them, and thus will they be forever, as long as He wishes them to be thus.

The uninformed³ say that the primary properties of the elements, and the properties of the things that are compounded of them, are contained in the twelve signs and in the planets, and they declare that Aries, Leo, and Sagittarius are warm and dry in accordance with the nature of fire; and Taurus, Virgo, and Capricornus cold and dry of the nature of earth; Gemini, Libra, and Aquarius warm and wet of the nature of air; Cancer, Scorpio, Pisces cold and wet according to the nature of water. And they say that some of those signs are movable, and some firm and immovable, and some neutral. They say also that some of them are male and some female, some light and some dark, and they say that some of the planets are good and some bad, and that some of them are favourable and auspicious for good people, and others unfavourable, adverse,

¹ “ Only nine spheres are here mentioned; though they are spoken of as ten in the very next sentence.” (Close)

² “Firmament - This seems as if the Second Sphere, or Sphere of the Signs, (cf Cha. 31), is to be called the firmament. But it is more probable that the Sphere of the Twelve Signs means the ‘Great Sphere’ (c.f. Cha 30). There is some transcriber’s blundering here. Whatever ‘Sphere of the Twelve Signs’ may mean, only nine spheres out of the ten are mentioned.” (Close).

It is my opinion that the ‘Very Great Sphere’ (*Speir Lanmhor*) and the Sphere of the Signs, *i.e.*, the Zodiac, (*Speir na Comartad*), have been inadvertently coalesced by a confused scribe. (JW).

³ “Among these must be reconned Ptolemy, who (if he really wrote, as is usually supposed, the *Liber Quadripartitus*), asserts some of these things, and Messahalal himself, who asserts them all.” (Close)

and inauspicious for bad people.¹ They say again, if the sun were not hot in its own substance, it would not perform the functions of heat which we see in terrestrial things, for it performs the very same functions in terrestrial things as does fire - which is hot in its own substance – namely; burning, parching, and charring.

They say again, that if the moon were not wet in itself it would not produce wetness in terrestrial things. Against this, I declare that that theory is scientifically incorrect and false; and I declare that the signs of the firmament are neither wet, nor hot, nor cold, nor good, nor bad; although it is from their union (together) and from their motion that they produce those properties; although (in themselves) they are not present in terrestrial things, because they were all made from one substance and one material; and I will explain this in more detail afterwards.²

* * *

15. SCIENDUM EST, ETCETERA.³

It is evident that it is not by their taste or by their odour that the natures of natural bodies are known, for if they were recognised by their colours, all white bodies would have the same nature, and everything of the same colour or taste would be of the same nature; for we see that snow and dough and fresh cheese have the same colour although each of them has a different nature. We see again that, although parsley and aloes agree in pungency, they are not of the same nature since one is sharp and the other mild; and in the same way we speak of smell. Consequently, not by their taste or smell or touch, is the nature of the natural bodies known, but by their positions and motions.

The ill-informed declare that the firmament changes⁴ in parts, or in its own entirety, with length of time, although that change is not apparent to us, as we see gold, iron, the body, jacinth and many other precious stones becoming discoloured with age and length of time, and changing in size, colour, taste and smell with length of time, although we are not aware of that change when it is in progress, on account of the great extent of time during which it is carried on.

I say to them in answer, that everything that is beneath the moon in the sphere of the four elements undergoes change, and that change is of two kinds - complete and partial - and those two changes concern growth and decay, and the complete change is more evident than the partial. Every body that is changed, undergoes that change in quantity or quality, and the actions of the body make that change evident to us; for when an unsound body becomes sound, and a sound unsound, it is the actions of that body that make that

¹ The author has unambiguously distanced himself from the realms of astrology. (JW)

² “But there is no return to this subject in this Tractate. Doubtless, there was such in the work from which this Chapter has been borrowed.” (Close)

³ This Chapter is not in the Latin of Stabius.

⁴ “The unchangeability of the firmament is from Aristotle, *De Coelo*, Book II., Chapter. 6.” (Close)

change evident to us. So, when a heavy body becomes light, the actions of the same body make that change evident to us. Thus, when a slow body becomes swift or a swift slow, it is the swiftness or slowness of that body that makes that motion evident to us.

Thus if the firmament were increased or decreased, its actions would manifest that change to us. For were it augmented and extended, and the constellations placed further from us than they are, we should see then a smaller quantity of them than we do now observe, and there are many of them which we see now, that we should not see then. Consequently, when it would have closed in around the earth, the quantity of the stars would seem to us more prodigious than now, and then we would see many stars that we did not see before. Now, since no one ever has seen these changes in the firmament, for if he had, it would be found written; it is sure and certain, that the firmament suffers neither increase nor decrease, and has neither contracted nor expanded.¹

Similarly if the firmament inclined to its right or to its left, or forwards or backwards, or if it moved up or down from the position in which it is, the centre, *i.e.*, the earth, must necessarily change with it but the earth cannot leave its own position, since it has no place to go; for every place around it is full of other bodies; and since two bodies cannot on any account occupy the same place, the earth cannot leave its own position to join other bodies, and consequently the firmament must be in a permanent, immovable, immutable position around the earth for ever. If it were said that the change of the firmament resulted from the failure or decrease of its substance, as the human body becomes weakened by ill-health, in the same way the motion of the firmament would be weakened, as is the walk of a sick man. In the same way the hours and seasons would be changed - a thing that has never happened, for they have always had the same course and have today, and will have it for ever.

Thus, since the substance, or quality, or quantity, or position, or motion, or time of the firmament, or of the rising, or setting, or concealment, or revealing of the stars are not changed, and since that has never happened, and never will happen, it must necessarily be one firm immovable system that it had, has, and will have, as long as He who created it desires, and it must have a nature other than the nature of the four elements.

* * *

¹ It is interesting to note that the possibility of an expanding universe is at least acknowledged in theory. The observation of these changes however, and their having been “written”, had to wait a further five and a half centuries. (JW)

16. QUI PERFECTE CIRCULOS LINEASQUE ETCETERA.¹

Whoever could perfectly understand the circles, lines and points of the firmament, would understand without doubt the nature of the whole firmament, and the proper way to understand it is to consider its form and shape as it is in itself, and ponder it carefully from the inside in your reason and mind.

The position of the first circle² of the firmament is as follows: - From the eastern point to the central upper point above the earth, and from that to the western point, and from that to the central lower point beneath the earth, and from that again to the eastern point whence it began at first. That circle is called “orientalis” and “occidentalis,” *i.e.*, the eastern or the western circle, and is also called the circle of the straight line, because when the sun is in that straight line, day and night are equal in the countries of the whole world. The situation of the second circle³ is from the point of the Arctic (Celestial) Pole to the upper point of the firmament, and from that to the point of the Antarctic (Celestial) Pole and from that to the central lower point of the firmament beneath the earth, and from that to the point of the Arctic (Celestial) Pole whence it previously began. There are three other names which philosophers apply to that circle – “septentrionalis,” “australis” and “meridionalis” - the northern circle, the southern circle, or the meridian circle⁴. The situation of the third circle⁵ is from the eastern point of the firmament to the point of the Antarctic (Celestial) Pole, and from that to the western point of the firmament, and from that to the point of the Arctic (Celestial) Pole, and from that to the eastern point of the firmament. This circle is called “circulus terminorum” or “circulus signorum” - the circle of the boundaries⁶, or the circle of the Signs⁷.

This is the position of the first of the three lines of the firmament, from the eastern point of the firmament through the middle point of the earth, to the western point of the firmament. The second line (is) from the central upper point of the firmament above the earth through the middle point of the earth, to the central lower point of the firmament beneath the earth. The third line (is) from the Arctic (Celestial) Pole through the middle point of the earth to the point of the Antarctic (Celestial) Pole.

Here below are the seven points of the firmament - six of them in the six places where the three circles I mentioned cross each other, and where the six ends of the three lines I mentioned are. The seventh point is the centre of the earth, which is the centre of the whole universe. The first of these points is situated in the east of the firmament in the place where “circulus terminorum” and “circulus orientalis” or “occidentalis” cross each other. The second point

¹ This Chapter is moderately close to Chapter 10 of Stabuis' edition of the Latin.

² “The celestial equator, or equinoctial line; but very insufficiently described.” (Close)

³ “This is the meridian circle.” (Close)

⁴ The meridian circle, - *cercall an medon lae*, lit.; circle of the middle of the day. (JW)

⁵ “ ‘The Third Circle’ , - There is much blundering here. A reference to Stabius shows that it is the *circulus horizontalis* which is here meant.” (Close)

⁶ Ir.; ‘*cercall na termine.*’

⁷ Ir.; ‘*cercall na comartadh.*’

(is) in the centre top zenith of the firmament, over the earth, in the place where “circulus orientalis” or “occidentalis” and “circulus septentrionalis” or “australis” cross each other. The third point, (is) in the west of the firmament, in the place where the “circulus orientalis” or “occidentalis” and “circulus terminorum” cross each other. The fourth point, (is) in the centre bottom of the firmament, below the earth in the place where the “circulus septentrionalis” or “australis” and “circulus orientalis” or “occidentalis” cross each other. The fifth point, (is) in the north of the firmament, in the place where the “circulus septentrionalis” or “australis” and the “circulus terminorum”¹ cross each other. The sixth point, (is) in the south of the firmament, in the place where “circulus terminorum” and “circulus septentrionalis” or “australis” cross each other. The seventh point, as I remarked, is the centre of the earth which is the centre of the whole universe, where the three lines I mentioned cross each other; and that is the situation and description of the three circles and the three lines of the seven points which I mentioned above. Whoever could understand them perfectly would understand the nature of the whole firmament.²

* * *

Concerning the different sunrise and sunset in many countries:

17. SOL PRIUS BABYLONI QUAM EGYPTO, ETCETERA.³

The sun rises earlier in Babylon than in Egypt and (earlier) in Egypt than in France, and, consequently, it sets earlier in Babylon than in Egypt, and earlier in Egypt than in France.⁴

To explain this clearly, I will place these three countries in a geometrical figure as an example of the rising and setting of the sun in the other countries of the world, but I suppose a space of six hours to be between Babylon and Egypt and between it again and France, and in the same way again between the other countries. Then I will describe a perfect circle in the form of the earth, and a circle larger than that outside it representing the orbit of the sun, and will place the letter A for Babylon and B for Egypt and C for Africa, and I will write D for the sunrise of Babylon and E for its noon and F for the sunset, and in the sameway, B for the sunrise in Egypt and F for its noon, and G for its sunset, and in the same way again, F for the sunrise of Africa and G for its noon and D for its sunset.

¹ “*circulus terminorum*” - horizon.” (Close)

² “There follows here, in the Latin of Stabius, an illustration of the above by a diagram with its demonstration, of about half the length of Chapter 16. Its omission here, however, is no great loss.” (Close)

³ This Chapter is not in the Latin of Stabius.

⁴ It would appear that the Irish author has substituted France for Africa in this example. The accompanying diagram refers to Africa. In addition, the RIA and Marsh manuscripts have been altered by a later hand to restore ‘Africa’ as the western location cited in the text. (JW)
 “ ‘Africa’ - This clearly means the original Africa proper, or the territory of Carthage.” (Close)

Thus, I declare when the sun rises at point D, it is visible to the inhabitants of Babylon, and is concealed from the inhabitants of Egypt until it reaches point E which is noon in Babylon, and sunrise in Egypt, and midnight in Africa, for then the sun rises with reference to the Egyptians, yet it is invisible to the inhabitants of Africa¹ until it reaches point F, which is the end of the day in Babylon, and noon in Egypt, and sunrise in Africa, because day begins then with reference to the people of Africa, and [it is] evening with the Egyptians and midnight with the people of Babylon. The Africans behold it until it reaches point D which with them is the end of the day and is midnight in Egypt and the beginning of the day in Babylon. And midnight in Egypt and the end of the day in Africa are at one point. At another point is the beginning of the day in Egypt and midday in Babylon and midnight in Africa. In the same way, at one point is the beginning of the day in Africa, and midday in Egypt, and the end of the day in Babylon. In the same way again, at one point it is midday in Africa, and the end of the day in Egypt, and midnight at Babylon.

Thus, according to the order of God, when the sun rises in some country in the world, it sets in another, and it is the roundness of the earth that causes that difference of sunset and sunrise in the world.

Here follows the figure I promised to make:

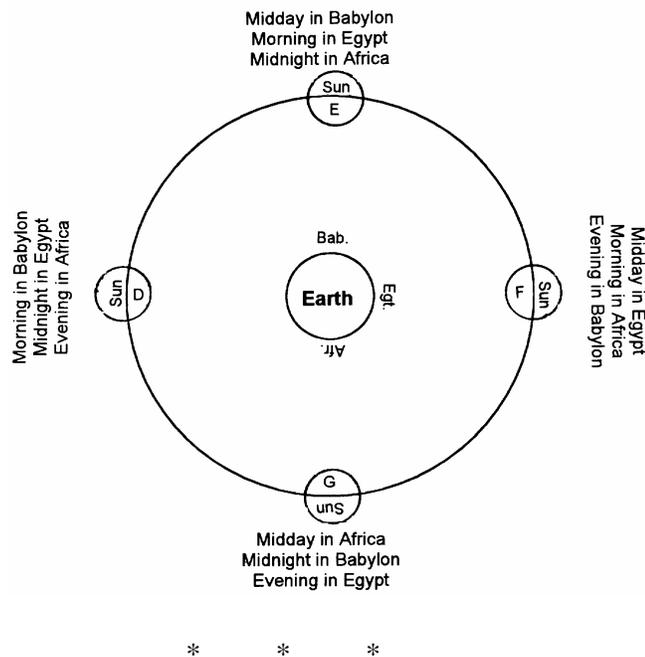


Figure 6²

¹ i.e., Carthage, North Africa.

² The quality of diagrams in the three surviving manuscripts varies considerably. As a general rule, those of ms Stowe B, are superior to those in the Marsh ms. Several diagrams exhibit considerable distortion to the point of rendering their relevance obscure. Figure 6 is one of these. I have taken the liberty of including here the amended version by Maxwell Close. It is in conformity with both the Irish text and the equivalent diagram in the Stabius edition. It would appear that drafting ability was not a pre-requisite talent for medieval scribes. (JW)

Concerning the size of the sun:

18. RATIONES GEOMETRICAE, ETCETERA.¹

The geometrical calculations of Ptolemy,² the astrologer³, prove the size of the sun. He says: The size of the sun must be (either) equal to, lesser, or greater than the size of the earth; and if the sun and the earth were equal, the shadow of the earth, *i.e.*, the darkness co-extensive with the earth itself, would travel out to the sphere of the fixed stars and obscure them, and an eclipse *i.e.*, deficiency of light in the moon, would occur every month the year for the earth's mass, which would be as large as the mass of the body of the sun, would deprive the moon and the stars of the sun's light, and there would then never be a moon, but constant darkness from the beginning of the night until the end. Therefore, since the moon is present and the stars are seen illuminated in the night, let it be understood from this that the sun and the earth are not equal to each other.

To make it clearly understood, I will make a figure⁴ of three circles around each other; the outer circle for the orbit of the fixed stars, the middle circle for the orbit of the sun, and the smallest circle for the orbit of the moon; and the earth in the middle, and the sun down beneath the earth in its own sphere co-extensive with the earth, and the shadow of the earth opposite the sun on the other side of the earth, and co-extensive with the earth passing out straight to the sphere of the stars.

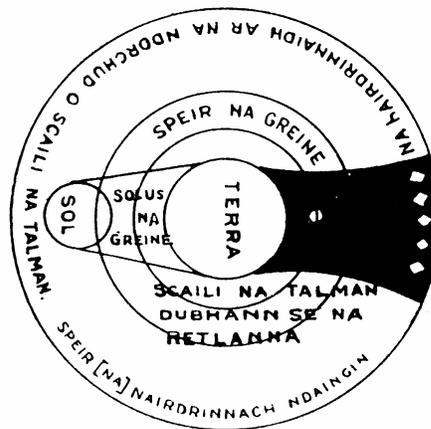


Figure 7

* * *

¹ “This Chapter is not at all close to the corresponding Chapter (8) in Stabius.” (Close).

² “The following treatment of the sun’s magnitude is not in the Almagest; though Ptolemy speaks of the size of the sun, making it very much greater than the earth, he clearly believed that the fixed stars shine by their own light; and moreover, being an able mathematician he could not have written the first and second divisions of this chapter.” (Close)

³ This reference to Ptolemy as an astrologer (from ms Stowe B), is not found in either the Marsh ms or the second RIA copy. Ptolemy is generally referred to simply as ‘the Philosopher’. (JW)

⁴ The figure reproduced here (as per ms Stowe B), is rather poorly constructed by the scribe, although, the meaning is still fairly obvious. (JW)

19. SI AUTEM SOL MINORIS ESSET QUANTITATIS, ETCETERA.¹

If the size of the sun were less than that of the earth, every unpermissible insufferable thing I have mentioned and more besides, would occur, because the shadow of the earth would be constantly increasing in size and width out from the earth to the sphere of the constellations, and it would darken the greater part of them² and an eclipse of the planets would occur every month, (*sic.*)³ and an eclipse of the moon, as I mentioned, would be in progress during the night until morning. Since, then, we have never seen this, and never heard of it, and never found it written, the size of the sun cannot be less than that of the earth. This figure below explains this statement I make.

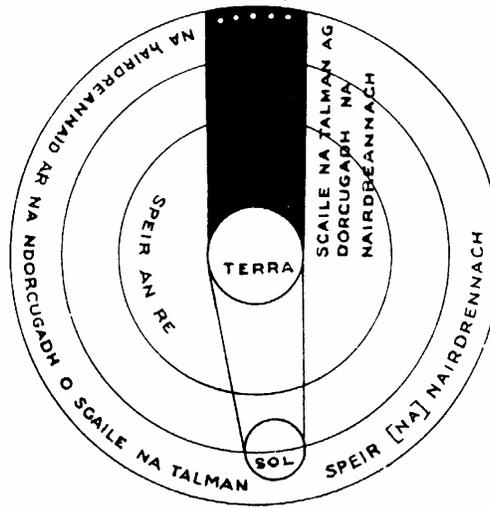


Figure 8

* * *

¹ “This part differs considerably from Stabius’ Latin; the matter being the same.” (Close). O’Farrelly designates this ‘Cha. 18, continued.’ (JW)

² Implicit in this statement is the assumption that the stars do not shine by their own light, but simply reflect light from the sun. Close adds that; “Isidore of Seville thought this; *De Reum Nature*, XXIV. See also his Lib. III *Originum, sive Etymologiarum*, Cap IX. Albertus Magnus thought the same; *De Coelo et Mundo*, Lib., II, Cap 16. Riccioli, in his *Almagestum Novum*, Tom.I, Pars I, Lib.VI, Cap II, tells us that the following entertained the same notion, *viz.*: Metrodorus, Albatani, Vitellio, Reinhold, Blancanus & Scheiner. Even Copernicus thought this.” Clearly, the Irish author has erred in good company! (JW).

³ “ ‘month’ - So in the two other Irish mss., and in Stabius. But the month is not concerned with the planets; though it is so with the moon.” (Close)

Substitution of the word ‘period’ would restore the intended meaning. The period of Saturn, for example, is elsewhere referred to in the Tract as 30 years. This is clearly an oversight on the part of the Irish author or a subsequent scribe. (JW)

20. NECESSARIO IGITUR FATENDUM EST.¹

It must be admitted that the size of the sun is greater than that of the earth, and that the shadow of the earth never extends up beyond the sphere of Mercury. The shadow of the earth is conical in shape, with the base towards the earth, while it becomes narrower by degrees, until it comes to an end a little above the sphere of the moon. The same shadow obscures the moon according as it spreads over it; for when the moon is in the north or south of the shadow, it obscures the portion of the moon on which it is, and when it spreads over half of the moon, the shadow obscures it completely. However, we know, and we have found it written, that that shadow of the earth does not reach the stars nor any of the planets, but only the moon which is neighbour to the earth, and therefore all the planets, except the moon, and the stars borrow light from the sun always; and thus he² proves that the sun is much larger than the earth, as this figure below shows.

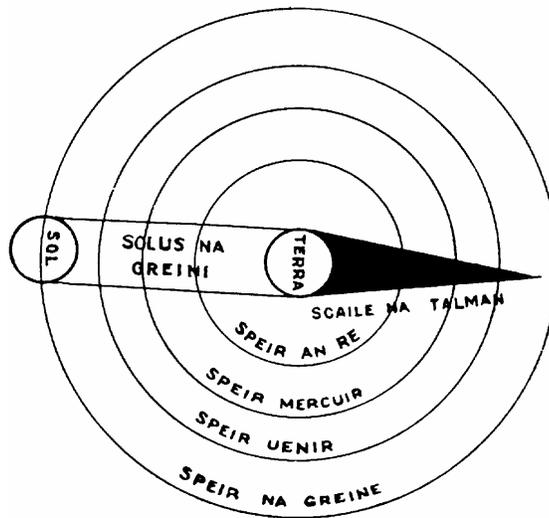


Figure 9.

* * *

21. LUNA NIHIL LUMINIS HABET NISI, ETCETERA.³

There is nothing light-giving in the moon except what it borrows from the sun, and both are spherical like the figure of a round ball; for if they were level planes, as the ignorant have asserted, when they would be in the east or west of the firmament, only the edges of them be visible, and they would be completely visible at the top of the firmament. Since they do not appear more clearly spherical in the highest point of the firmament than in any other of those places, let it be understood that they are spherical, and not flat.

¹ "This part differs considerably from the Latin of Stabius." (Close)

In O'Farrelly's edition, this Chapter is designated 'Cha. 18, continued.' (JW)

² i.e., Ptolemy

³ "This Chapter is by no means close to Stabius' Chapter 9." (Close).

That spherical portion which we see in each of them is only a hemisphere, i.e., half a sphere, and the other half is not visible. Thus, it is clear that the sun, moon, planets, and stars have all a spherical form, for from whatever side they are viewed, they appear round.

As I have said, the moon has no light of its own nature, and it is dark and reflective like iron which has been polished; and whatever light it has, it borrows from the sun; and its sphere is the sphere that is nearest the earth, between the heavenly bodies, and the sphere of the sun is the fourth above it. And, although they are far from each other, the moon is beneath the sun in exactly the same degree as it, then it illumines the upper part of the moon and the side near us is dark, and it is full dark moon with us. Therefore we see nothing of the moon at that time.

When the moon leaves that exact degree in which it is beneath the sun, and moves by degrees away from it eastward, then the light moves by degrees westward.

The light which the upper part of it borrows from the sun, illumines the lower edge of it, and then the moon is in its prime, i.e., with its first light turned to us, for that is the first course in which we see it; and the further eastwards it moves from the sun, the more does the light of the upper parts come round it from above, and the further eastwards it goes from the sun, the greater the increase of its light in the west, and the increase of its darkness in the east, until it reaches the 14th day, because then it is furthest from the sun, and is exactly opposite it on the other side of the earth, and then the hemisphere which is nearest the earth is completely light, and the upper hemisphere completely dark. Thus, it is never without its dark half and its light half, whatever course it takes.

When the moon inclines westwards from the diameter of the sun, i.e., from the straight line in which it is, to the other side of the earth opposite the sun, the light of the moon beside us moves upwards by degrees, and the same area of it is darkened at its wane as has been illumined at its prime, and thus, as much of it as is illumined ever night for fourteen nights, is darkened every night from then until the end of the month, until it is exactly beneath the sun in the same degree as it [the sun], between it and the earth, and then the side towards us is dark and the side above light.

And to make this clearly understood, I will make a figure here below in which I will place the sun to one side of the earth - the western side - and the moon 12 degrees eastwards from it, a little over the earth, and I will make it all dark except the western edge of it which is nearest the sun, which shows it to be at its prime.

sun and the earth, light. I will place the sun as having set at that time at one side of the earth, etc. Here yonder is the figure itself.

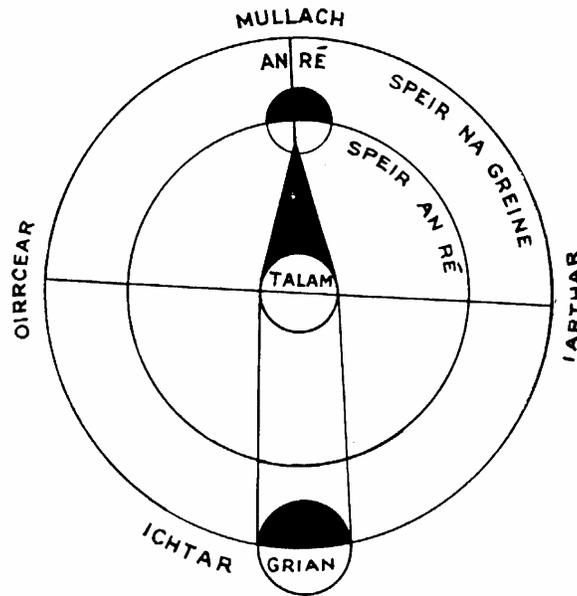


Figure 12

I will make moreover a fourth figure, and will represent the half of the moon which is nearest the earth light, and the other half dark, as the moon is on the twentieth¹ day of the month, and I will place it exactly in the east, and the sun exactly in the middle beneath the earth.

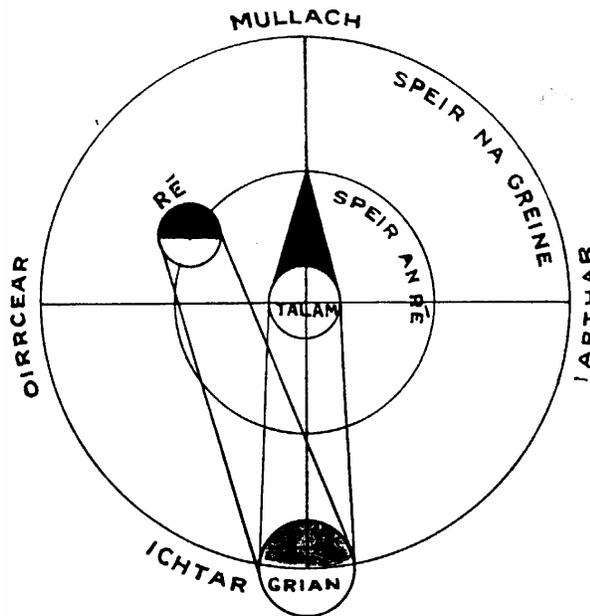


Figure 13

¹ The three ms copies of the Tract record conflicting dates. The second RIA copy retains the most suitable figure and is used here. (JW)

After that I will make a fifth figure in which I will place the moon at the top of its own orbit in the same degree as the sun, and represent the upper half of it light and the lower dark. Here is the figure on the other page. (*Fig. 14*)

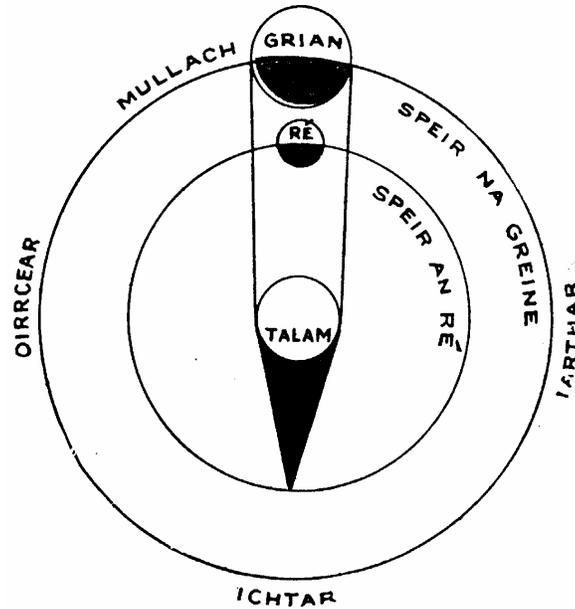


Figure 14

* * *

Concerning the cause of the eclipse of the moon:

22. POSTQUAM ARGUMENTIS, ETCETERA.¹

Having proved by forcible arguments and geometrical figures that it is from the sun that the moon and all the stars receive light, we shall now show whence comes the natural darkness upon the moon which is called an eclipse and I declare, approaching that subject, since the moon receives its light from the sun, and there is nothing else to deprive it of that light except the earth, it is the shadow of the earth, which is exactly between the sun and the moon, which envelopes the moon and deprives it of the sun's light; and that obscuration of the moon by the shadow of the earth is an eclipse. Now this would occur without fail, if every time the moon meets the head or tail of the Dragon, it were in a straight line, right opposite to the sun and the earth; it then would penetrate the shadow of the earth, and be totally obscured.² When the

¹ "This Chapter is not very close to Stabius' Chapter 11." (Close)

² "This sentence is much corrupted in the Irish, but the slight changes we have introduced have brought it back to what was clearly intended. It is right in Stabius." (Close)

The change referred to by Close is the restoration of the conditional voice to the verb. I have amended Power's translation to accommodate this correction. Other minor changes would

moon advances to the south or north of that shadow, it avoids the total eclipse, and on whatever side it meets that shadow, the portion of it which is beneath that shadow is eclipsed.

Therefore, there are two kinds of eclipse, i.e., *eclipsis universalis*, i.e., a general eclipse, and *eclipsis particularis*, i.e., a partial eclipse. Wherefore it does not begin at the same time in every place, and is not of equal size in every place, since it is not of the same size in the east as in the west, and neither is it the same in the south of the world as in the north. On that account it [the eclipse] does not appear the same to people in the countries of the world, and they on whom day rises do not behold it, though it is present naturally at that time. Afterwards, I will speak of the eclipse of the sun in its own place.

The eclipse of the other planets: One of the planets themselves is the cause of the eclipse of the others, for the lower planet obscures the higher. In the same way, the moon obscures them all, each at its own time. To explain better what I have said of eclipses, I will make a geometrical figure here below, from which the, eclipse will be clearly understood.

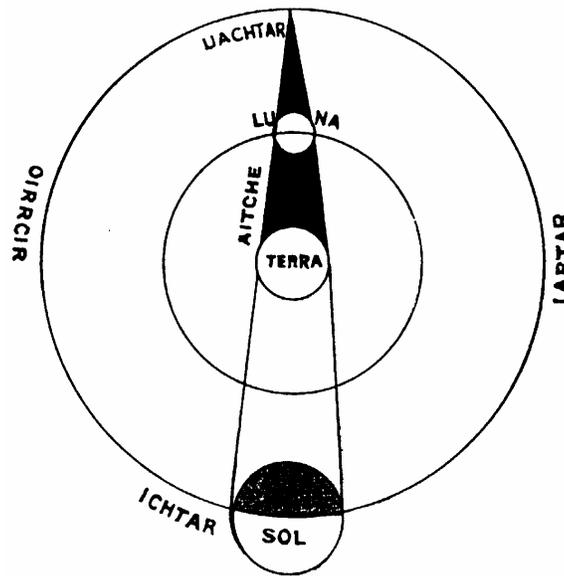


Figure 15

* * *

also restore the original intent of the author. One of these is footnoted in the Irish text in Appendix II. (JW).

23. MANIFESTUM EST, ETCETERA.¹

It is evident as I have stated, that the light of all the stars comes from the sun², and that they are round like a ball, like the sun and moon, and the reason why their roundness is not evident as is the roundness of those other two, is because they are all above the sun, far from us, except Venus and Mercury; and half of each star which is above the sun is illumined by it [the sun] at whatever point of their own orbit these stars are; i.e., whether they are in the same degree as the sun or whether they are far from it, or near to it, or in front of it, or behind it, from it they all receive light. Every time any of these planets, that are above the sun, are directly in front of it, then their light is most prodigious in front of the earth for two reasons. The first reason: A person who is in darkness thinks the light he sees outside the darkness more brilliant than a person who is in the light itself, and accordingly the person who is in the thick dark shadow of the earth at night, as he beholds the planets that are directly in front of the sun, considers the light prodigious on account of the intense darkness which surrounds him.

Another reason is that whenever any of the planets is placed directly opposite the sun, it behoves it to turn back on its circuit, and its light is all the greater in consequence of that retrogression, for it is thereby nearer to the earth; and this never happens except in the planets which are above the sun.³

The planets that are beneath the sun, i.e., Mercury and Venus, never arrive opposite the sun, and are never in the quadrature aspect. Not thus are they, but near it always, before or behind it, and the nearer they are to the sun, the less is their light, and the further they are from it the greater the light.

The light, however, of the planets that pass opposite the sun, is always increasing by degrees, until they reach the place beyond which they cannot go, and where they must turn towards the sun again, and during that retrograde motion, their light is on the decrease until they are in the same direction as the sun, beneath it, then the half of them nearest the sun is light and the other half dark, as I said in reference to the moon, when it is in line with the sun; for it is never visible except when it is at least fourteen degrees to one side of the sun, i.e., at its prime, or at its extreme wane.

¹ This Chapter is moderately close to Stabius' Chapter 12, except that the last three diagrams with their demonstrations are not in Stabius.

² Concerning the statement that the 'light of the stars comes from the sun', Maxwell Close makes the following comments:

"Muller states that Copernicus believed this. . . . See Copernicus *De Rev. Orb. Cel.*, Cap 10, towards the end. He there implies that the sun is the lamp which illuminates the whole temple [of the universe] and that it is suitably called *lucerna mundi*."

See also footnote 72 (Chapter 18).`

³ This paragraph is taken directly from O'Farrelly's translation. Power's version has obscured the meaning of the text, seemingly due to a lack of familiarity with the geometry of 'retrograde' motion. (JW)

Those planets¹ are also after the same manner; for when they are to the east, twelve degrees in front of the sun turning towards the sun, or when they are in motion twelve degrees to the west of the sun they appear horned², after the manner of the new moon, and when they come away from the sun, as they cannot advance further, they have their full light, although that change is not evident to us as is the change of the light of the moon, as they are much further from us than the moon. Therefore, when their light is great, their bulk is small on account of their distance from us. When they are nearest the earth, the beam that comes from them appears now long, now short, and now quadrangular, according to the shape of their body. When they are furthest from the earth, not thus does the same beam appear but round, as is fire distant from you; whatever shape the flame naturally has, narrow or long or broad or short, not so does it appear when far from you, but round.³

Here below is the figure that will clearly show how the sun illumines all the stars, as well as the planets; and the meaning of this figure shows there is the furthest distance they can go from the sun, i.e., in no place in the universe that is not brightened and illuminated by the sun.

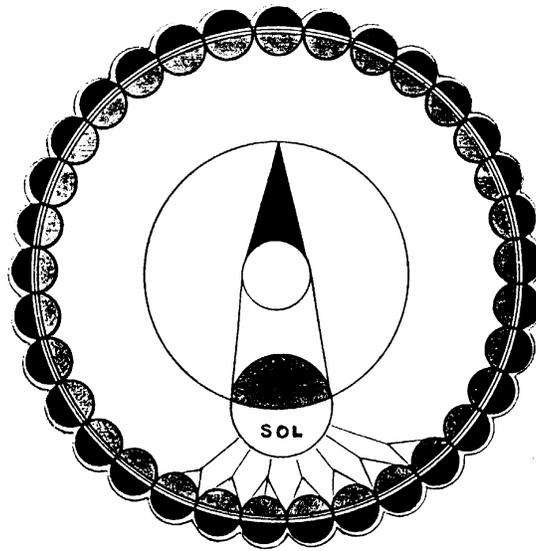


Figure 16

I will make again another figure to show how Venus and Mercury, which are beneath the sun, are illumined by it, and how they come into the same degree as the sun, as near as they can go to it.

¹ Close was at pains to point out that this only applies to the planets whose spheres are below that of the sun, ie, Mercury & Venus. I have not included his 'interpolation' to 'rectify' the text. In my opinion, the implication is obvious from the preceeding paragraph. (JW)

² This 'horned' effect, the predicted phases of the planets, was not actually observed until Galileo directed his telescope towards Venus nearly two centuries later.

³ Close was of the opinion that there has been some corruption of the text in these last two lines. I am not so inclined. The intended meaning seems reasonably clear and logical. (JW)

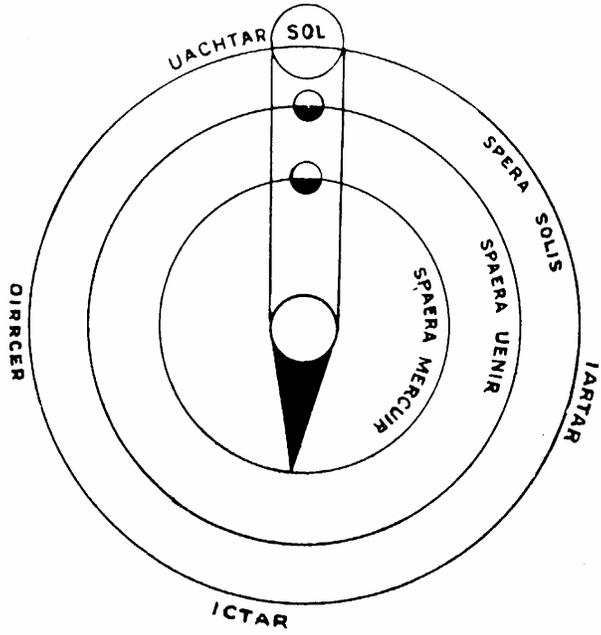


Figure 17

I will make again the third figure here to explain better than this, how Venus and Mercury are illumined by the sun, and I will place them in the east of its orbit above the earth, so that they cannot go a greater distance from the sun than they are in front of it at dawn.

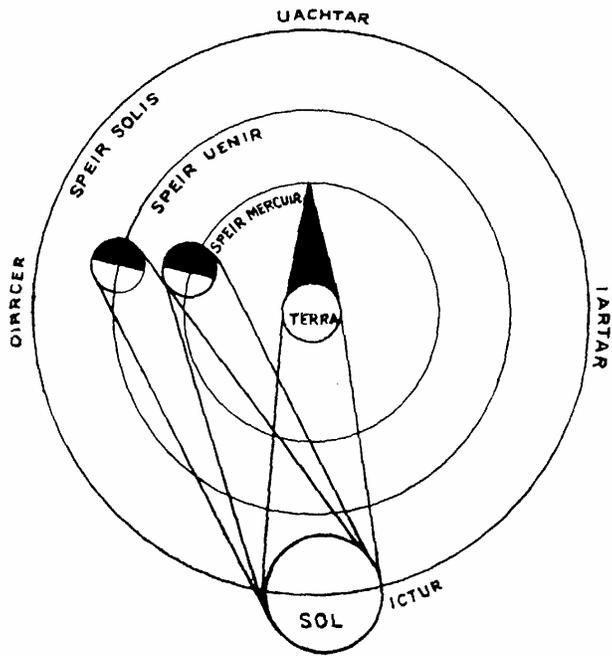


Figure 18

Now I will make the fourth figure to demonstrate better how they obtain their light, and I will place them on the western side of the sphere above the earth, as far as they can go from the sun; in the position in which they are being followed at every time.¹

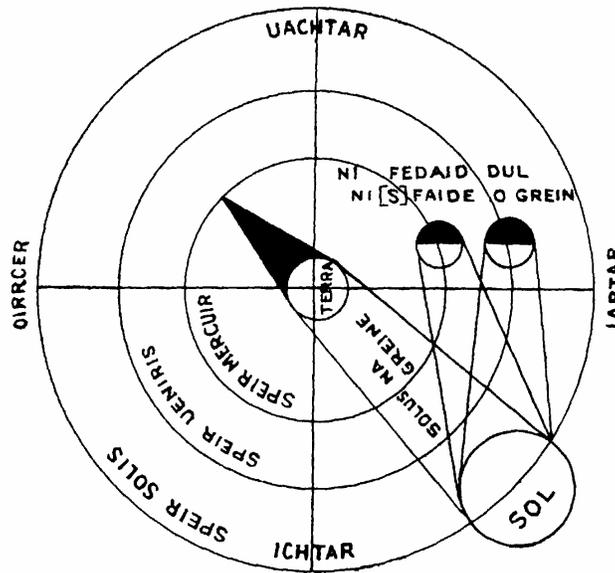


Figure 19

* * *

24. DICO QUOD LUNA SOLI CAUSAM ECLIPSIS, ETCETERA.²

I declare that the moon is the cause of the eclipse of the sun, because its sphere is the lowest of the heavenly spheres, and the sphere of the sun is the fourth sphere above that, and, accordingly, every course it makes is beneath the sun. When it arrives at the head or the tail of the Dragon, in exactly the same degree as the sun, without inclining to the south or to the north, it deprives us of the light of the sun, and that darkness is an eclipse. When, however, it [the moon] inclines to its right or left side, and does not move exactly in the head or in the tail of the Dragon beneath the sun in the same degree as it, it avoids producing an eclipse. That darkness which is seen on the sun, when there is an eclipse, is the body of the moon. Therefore, it is evident that an eclipse never occurs, except when the moon is exactly beneath the sun in the same degree as it. It always begins to the west side of the sun and finishes in the east. When the moon moves outside that exact degree of the

¹ This last line is in conformity with OFarrelly's translation. (JW)

² "This Chapter is not very close to the corresponding Chapter (13) in Stabius; but it is superior to that chapter on the whole. Nevertheless, it requires some correction to make it right." (Close).

sun, it sometimes obscures a portion of the sun from us. Therefore, an eclipse of the sun is of two kinds as is an eclipse of the moon, i.e., total and partial.¹

The eclipse varies in various lands, for when there is an eclipse, it is not visible to the same extent in every land, for there is one land in which it is visible, and another in which it is not, and one land in which it is more visible, and another in which it is less visible; in this wise: - If the sun were in the straight line up over our heads and the moon in the same line beneath it, it would necessitate an eclipse for us. If a person were at the same time in the east of the world, looking at the sun, he would imagine he saw it in the west of the world, and if there was another person at the same time in the west of the world beholding the sun, he would imagine he saw it in the east of the world, but neither of them see the eclipse of the sun because the sight of each would pass exactly between the sun and the moon, and, consequently, the moon, or any dark body, even though it were in the straight line beneath the sun would not deprive them of the sun's light, because of their distance from that line. At the location in which the sun is thus obscured, the stars are visible in the daytime, so great is the extent of the darkness.

An eclipse of the sun is of shorter duration than an eclipse of the moon on account of the rapidity with which each passes the other, but not so is an eclipse of the moon, which is caused by the earth. There is nothing interfering with it but the course of the moon above whilst the earth is stationary.

If anyone opposed me in this by saying that the moon is not the cause of the eclipse of the sun, and that if it were as I said, would it not also be fitting for it to be eclipsed by Venus and Mercury when they are in the straight line beneath the sun, I answer him thus: When Venus and Mercury are beneath the sun in the same direction as it, they are (as always) far away (from us) and (hence) in that position, they are much less than the sun in (apparent) size and breadth.²

The same thing often happens to the moon, for it is often beneath the sun in the same direction as it, while it is far from being as broad as it.³

¹ *Total and partial* are in Irish, (*eclipsis uili & eclipsis rannaighi*), but not in the Latin of Stabius. Likewise with Chapter 22 on the eclipse of the moon. (JW)

² I have altered Power's translation to conform with the interpretation of O'Farrelly and Close. The passage is clearly talking about the relative apparent cross-sectional areas of the bodies distant from an observer on earth. (JW)

³ I have similarly adapted this sentence to also conform to O'Farrelly's translation. Maxwell Close makes the following pertinent comment on this speculation:

"This is interesting as being a clear reference to an annular eclipse of the sun; or at least the possibility of such. Delambre says (*Astron. Avicenna*, Vol. I, p. 229) "*Quelques anciens ont rapporté que les eclipses centrales laissaient voir une couronne lumineuse autour de la lune*". But Narrien, *Origin and Progress of Astronomy*, p 266, states that no mention is made by any of the Greek astronomers of an annular eclipse of the sun, and that if indeed, such would be impossible if the apparent diameter of the moon, in apogee, were equal to that of the sun, as Ptolemy believed it to be."

By way of interest, one of these rare 'annular' eclipses was recorded as having occurred when King Håkon IV (the Old) of Norway sailed from Bergen with his Norse fleet to punish the king of Scotland. As he landed in the Orkney Islands, the sun appeared as a thin, bright ring. The British physicist Sir David Brewster found that an annular eclipse of the sun was visible

In the same way an eclipse of the sun is not caused by the stars of less magnitude than the moon, which are nearer to it, because, when a small body is placed under a large body near it, the nearer it is to it, the less of it it conceals, and when it is placed far away from the large body, and near the sight which is looking at both, the further it recedes from the large body, and the nearer it approaches the sight, the more does it conceal the large body; so that in this manner a wild apple would conceal the body of the sun from the sight.

To explain this, I will make a figure¹ here below in which I will make a large circle, like the orbit of the sun, and will place the sun up at the top of it, and make another circle inside that like the orbit of the moon, and place the moon itself up at the top of it in the straight line under the sun, and I will make the third circle inside that in the form of the earth and place the letter E in the centre of it and assume it to be the point in the earth whence men behold the sun, and put A in the east and B in the west of the sphere of the sun, and place the human sight in the straight line from E and from A and from B towards the sun.

Therefore the people in E see the eclipse of the sun clearly, and the same company that are in A and B see the sun clearly without an eclipse because the moon is too small compared to the sun. It does not conceal the sun from them, and consequently, on account of their distance from the sun their sight passes easily above the moon towards the sun.

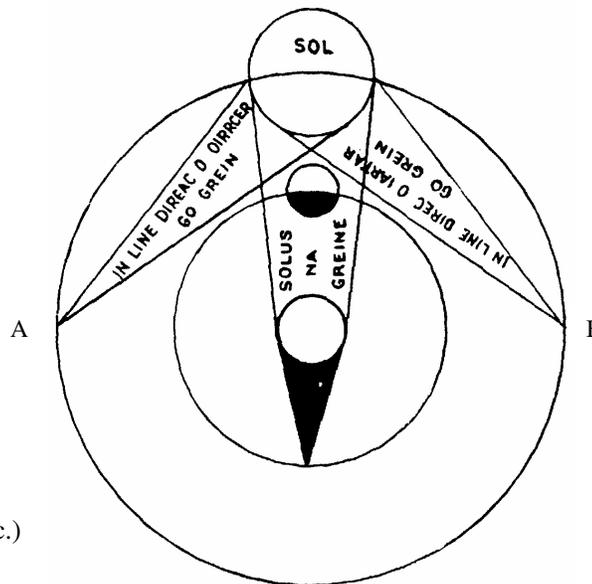


Figure 20 (sic.)

in the Orkneys on August 5, 1263, about one o'clock. It is possible that this event was still in living memory at the time of compilation of the Tract. (JW)

¹ The relevant figure in the surviving manuscripts is incorrectly drawn and the Irish text is similarly corrupted. The corresponding figure in Stabius is also deficient, but not so the text in Stabius. The figure in Stabius has obviously misled the Irish author. To restore the sense of this example, positions A and B should be taken as the most easterly and westerly points on the surface of the earth. I have retained here the erroneous figure from the Tract (*Fig 20*). (JW)

25. LUNA NON VIDETUR PRIUSQUAM, ETCETERA.¹

The moon is never visible, until it is twelve degrees from the sun, because the brightness of the light of the sun prevents us seeing it. And it is twelve degrees from the sun when it appears facing us in the beginning and then it is at its prime² i.e., at its first light. And the sun sets in regard to the inhabitants of the east of the world when the moon is eleven degrees from it before it is seen, while to the inhabitants of the west of the world it is shining clearly, when the moon is twelve degrees or more from the sun. Therefore the inhabitants of the west of the world see the moon sooner than the inhabitants of the east by one day. Consequently, when the moon is twelve or thirteen degrees from the sun, or a little more, the visible size of it is small, and when it is from eighteen to twenty-three degrees from the sun, then its size is greatest.³

* * *

The characteristic of the light of the moon and of the constellations:

26. DICO QUOD LUNA AC SIDERA, ETCETERA.⁴

I declare that the moon and the stars appear within the same time and season, bright in one country, and dark in another. The reason why the people of one country see them with their light, is because the night is on their side at the same time. The daylight prevents the people of the other country from seeing them, yet it is not the daylight that causes that, but the weakness of men's sight. Thus the moon and the stars are concealed from the country in which the sun is visible during that period, and when it [the sun] is concealed, it renders them visible. And thus is fire and every other light-giving object; though they are far from you at night their light is prodigious and though they were near you in the day their light is not great. Then if you mean to see the stars by day, go in the morning or evening into a dark deep pit, and look up,

¹ "Not at all close to Stabius' Chapter 14." (Close)

² Close made the following comment concerning the reference to the moon in its prime, both here and elsewhere in the Tract:

"In the Latin it is represented by *innovatio, innovatur, innovata*. The Moslems and the Jews, at least for some time, made the first appearance of the young moon to be the beginning of the new month. 12° 'or somewhat more' is the usual angular distance from the sun at which the young moon first becomes visible, according to Messahalal. According to Albatani, the distance varies from 10°50' to 13°30', under different conditions."

³ "This sentence is not in Stabius. There is some corruption of the text here." (Close)

The full moon is obtained at an angular displacement of 180° from the sun, as anyone with even elementary knowledge of astronomy would have known. It is possible a subsequent scribe has mistakenly entered 18° in place of 180°. Or is it an equivalent of our modern day 'typo' on the part of the Tract's author? The 23° is erratic and can only be explained by a later corruption of the text, presumably by a scribe unacquainted with astronomical matters. It is not difficult to envisage the occasional monastic scribe who doubled up as a reluctant lecturer, struggling at times to keep a page ahead of his students. (JW)

⁴ Moderately close to Stabius' Chapter 15.

and you will see them clearly over your head at the top of the firmament. Also you will see them clearly at the time of an eclipse of the sun.¹

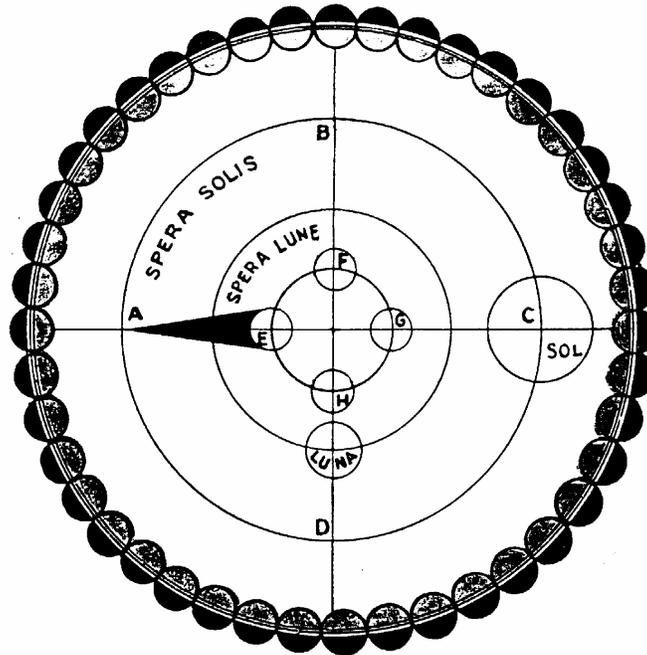


Figure 21

Now I will describe a circle for the orbit of the fixed stars in which I will place a diagram of many of the great stars. Inside of it, I will make another sphere for the sphere of the sun, in which I will place the sun itself, and inside of that I will make another sphere for the sphere of the moon, in which I will place the moon itself at the end of the thirtieth day from the beginning of the month. I will make a fourth sphere within these, and write I in the centre of it, and A in the east of it, and B at the top of it, and C in the west of it, and D at the bottom of it, and let four cities be represented by the four small circles on the orbit of the earth and four letters which mark these four cities; E the eastern city and F the upper one, and G the western city, and H the lower one; and thus when the sun sets, its light leaves city F and the beginning of night approaches it, then it is midnight in the city E, and at that time the inhabitants of the other city behold the stars with their full light and the moon rising in the east, half illuminated, and when the moon reaches city H it is then at the top of the firmament, and when the sun rises in the east of that city the inhabitants of the city cannot see the moon or the stars. When the sun arrives over city G, it is at the top of its orbit, and then it is mid-day, and the moon is there in the western half of the world over city H, and the stars do not show their light to the inhabitants of city G.²

* * *

¹ This last sentence is not in Stabius. It gives the distinct impression that the author may have witnessed such a total eclipse. (JW)

² Concerning this last rather cumbersome explanation, Close made the following laconic comment; "Confused, but right. Fair enough in Stabius".

27. CONSTAT QUOD QUATUOR SPHAERAE LUNAE, ET CETERA.¹

The learned relate that the moon has four spheres. The first of them is called the “Great Sphere,”² and with its own excessive speed, it carries the moon with it, making one revolution in a day and night around the world, and causes it to rise in the east and sets in the west in that course.

If this great sphere did not move the moon one course from the east of the world to the west in a day and a night, as I mentioned, the moon would be visible every day and every night without concealment from the time it would be at its prime in the west moving gradually eastward, until at last it would be in the middle of the month eastward, in the east of the world. At the setting then, it would be concealed by day and by night, until it would rise again in the west at its prime at the beginning of the next month. Thus the revolution of the great sphere I have mentioned, carries the moon with it during the day and night, from the east of the world to the west, but the direct motion of the moon itself is from the west of the world to the east. It is clear that this is so, for when the moon is at its prime in the west, we see it every night moving gradually eastwards, until it arrives at the east of the world, and this is the motion that is most natural and appropriate to it, for this is the motion of the sphere in which it itself is fixed, while that other motion which moves it from the east to the west of the world in a day and a night is only a forced unnatural one.

The second sphere of the moon is called “the sphere like the sphere of the signs.”³ When it is in this sphere, it is visible going into the signs and out of them for when it advances towards the southern signs, it swerves from them yet it never leaves the course of the sphere of the signs.

The third sphere of the moon is called “the eccentric sphere,”⁴ and portion of this is near the earth, and the other portion is very far distant from it, and on that account the moon in that sphere is at one time near the earth, and at another far from it; and the motion of that sphere is from the west to the east of the world.

In the body of that sphere is another small sphere, called “the sphere which revolves downwards to the moon,”⁵ and the sphere of the moon is firm and immovable in that sphere like a nail in a board.⁶ This little sphere, which is

¹ “This Chapter is moderately close to Stabius’ Chapter 16. When it is said that the moon has four spheres, two of them being the Great Sphere and the Sphere of the Signs, it is meant only that the moon participates in the movements of these two spheres, while having two proper to itself. So with the other planets, we are told expressly that the Great Sphere governs all the others which are inside it and causes them to turn from east to west. Eudoxus, however, thought that each of the planets had a complete set of such spheres to itself.” (Close)

² *Speir mhor.*

³ *Speir cosmail re speir na comartad.*

⁴ *Speir sa sentrom ata let amuith da tsentrom na talman.* Lit.; “the sphere whose centre is outside the centre of the earth”. (JW)

⁵ *Spheir impoides le anuas cum an re.* The Irish author is here referring to the ‘epicycle’ in Ptolemaic terminology. (JW)

⁶ The example of the nail in a board is not in the Stabius edition of Messahala.

within that sphere in which the moon is fixed, moves eastwards, and when the moon reaches the top of the aforementioned sphere, it accelerates its course; and when it is at the bottom of it, it relaxes the same course and when it relaxes, it performs something of a backward revolution westwards as the other planets do, although that revolution is not evident, as is the revolution of the planets. On account of the great swiftness of the eccentric sphere in turning the moon with it, that turning prevents the backward revolution of the moon being visible. Now I will make a figure showing those four spheres.

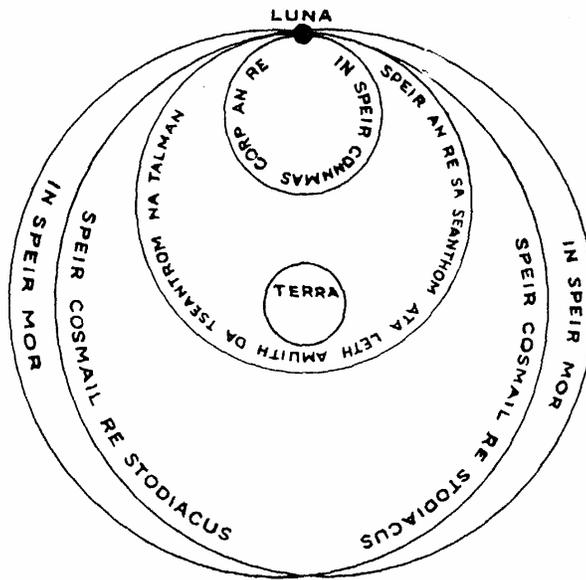


Figure 22¹

* * *

¹ “In this diagram, correctly copied, the eccentric should not have been made to touch approximately, the outer circles; nor should the epicycle touch the eccentric; its centre should be on the eccentric. Similar objections are to be made to Figure 23.” (Close)

Concerning the spheres of the sun.

28. DICO QUOD SOLI BINAЕ SPHAERAE, ETCETERA.¹

I declare that the sun has two spheres. The first in accordance with the very great sphere,² which moves westwards, and advances from the east to the west of the world. If the motion of that sphere did not check the sun, it would be six full months journeying from the west to the east of the world above the earth without setting. It would be an equal length of time moving from the east to the west of the world invisible, and thus half of the year would be one day and the other half night.

The second sphere of the sun, called “the eccentric sphere,”³ is like that of the moon. The motion of this sphere is from the west to the east of the world, and this sphere containing the sun within it is near the earth on one side, and distant from it on the other side. When the sun is near the earth⁴ in that sphere it parches the southern portion of the earth greatly, so that that land is uninhabitable; and when it is furthest from the earth in the same sphere, its heat does not reach the earth, and a corresponding portion of the northern part of the earth is uninhabitable⁵ from excessive cold.

Now I will make a figure to show how those two orbits of the sun are within each other.

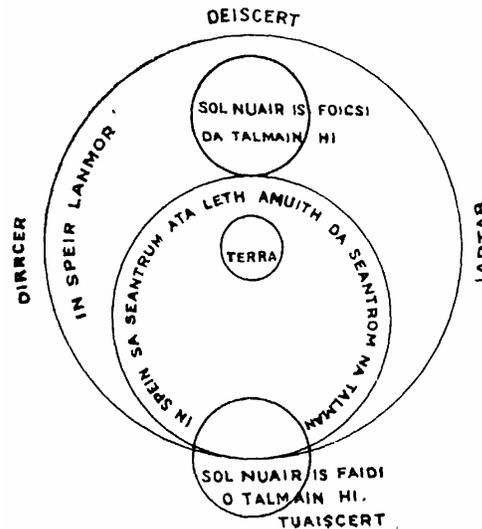


Figure 23

¹ This Chapter is moderately close to Stabius' Chapter 17.

² *Speir lanmor*.

³ *Speir sa seantrum ata leth amuith da sheantrum na talman*; lit., 'sphere whose centre is outside the centre of the earth.' (JW)

⁴ "Here use is made of the varying distance of the sun in its eccentric" (Close). – Plausible in theory, but in practical terms, the sun's 'eccentric' (within a geocentric framework) is too small to yield significant variations in the earth's climate. (JW)

⁵ "The Irish Tract has this point correct. The Latin edition of Stabius has here '*ubi est habitatio*'. The '*non*' has clearly dropped out. It must also be remembered that the Latin translation used in the writing of this work was not that of Gerard of Cremona, and hence not the Stabius edition." (Close)

Concerning the order of the ten spheres.

29. SICUT DICIT PTOLEMAEUS.¹

As that philosopher² says, we see two kinds of motion in the firmament - one motion from east to west and the other from west to east of the world. [The motion of] the sun, moon and each of the other five planets corresponds to the extent of the amplitude of their own spheres in the eastward motion. The westward motion moreover carries the planets with it in a contrary direction, in opposition to their natural motion which is eastward. I repeat that the sun moon, and other five planets and all the fixed stars have the same equal motion³, for of them all individually, there is no star which moves more swiftly or more slowly than the other. Therefore, there is no difference in the world between the motion of the sun and moon, and the motion of the other stars, because it is certain that they have the same nature and form. Although Saturn appears to be slower than the moon in consequence of the reason I shall now relate, their motion is equal.

As Ptolemy and the other philosophers declare, there are ten large spheres⁴, and the largest sphere of those, which is called the Very Great Sphere, possesses the same motion as the Sphere of the Signs, since both move westward. The motion of the eight spheres moreover, i.e., the sphere of the fixed stars and [that] of the sun and of the moon and of the other five planets, is from the west to the east of the world, as I have frequently remarked, and those spheres are situated within each other; and the sphere of the moon is the nearest to the earth, and then the spheres of Mercury and Venus respectively, and that of the sun outside those, and the spheres of Mars and Jupiter outside those, and the sphere of the fixed stars outside those. It is not because, they do not move that they are called fixed stars, for they move from the west of the world to the east, as do the other planets, but because they do not incline from the north of the firmament⁵ to the south, as do those others. The Sphere of the Signs is the ninth sphere, and outside those one and all is the tenth sphere called the “very great sphere,” or by another name, “the direct (or right) sphere.”⁶ Herewith is a figure⁷ which represents them all.

I said above that the moon appears swifter than Saturn. If the moon were in the orbit of Saturn, it would be thirty years travelling as Saturn travels.⁸ Similarly Saturn would traverse the orbit of the moon, if it were in it, in a period of

¹ “This Chapter is unusually close to the corresponding Chapter 18 in Stabius.” (Close)

² i.e., Ptolemy.

³ “i.e., If we neglect the inequalities arising from the effect of epicycles and eccentrics. This idea of the equality of linear velocities is derived from Aristotle. (*De Caelo*, lib.II, cap.10.)” (Close)

⁴ “Ptolemy mentions only eight. He has no *Great Sphere*, and no *Sphere of the Signs*. His *Sphere of fixed stars* performs its two motions automatically, the diurnal and the precessional, without being carried around by any external agent. Messahalāh’s ninth sphere is inconsistent with Ptolemy.” (Close)

⁵ “‘Firmament’ seems here to mean the sphere of the fixed stars” (Close).

⁶ *Speir direch. Orbis rectus* in the Latin of Stabius. (JW)

⁷ See Figure 24.

⁸ This compares favourably with the known value for the period of Saturn; 29.4 years. (JW)

twenty-seven days, or four weeks, less a day,¹ as it does itself.² And therefore it is the narrow compass of revolution which some of them have, and the extensive circuit of others, which causes the planets in them to appear fast or slow; though they are not so, for their course and nature, their speed and slowness are quite alike. And if the sphere of Saturn were divided into three hundred and sixty equal parts, to the centre of the earth, and each part of them were formed into a circular shape, each part of them would be equal to the sphere of the moon. And if the sphere of the moon were extended so as to add to its own extent, three hundred and sixty times as much, and all that were to be put in the form of a sphere, none the less would it be equal to the sphere of Saturn.³ Thus it is proved that it is the narrowness and the wideness of the orbits of the planets that makes some of them appear to have a swift and some a slow movement, although as I have repeatedly stated, such is not the case.

Ptolemy⁴ gave a clear example to explain the two motions I mentioned above, from east to west and from west to east of the world. Imagine that a wheel⁵ revolved from the east of the world to the west in a day and a night, and that there was a small circle around the centre of that wheel, and a circle twice as large outside it, and a third circle outside that three times as large as the first circle, the fourth circle outside of that four times larger than the first circle, and so on up to the eighth circle. And if a ball⁶ were in each and every circle of them, moving from the west of the world to the east (with equal linear velocities), then this wheel would represent the very great sphere of the world and the small circles I mentioned would be like the inner circles of that great sphere. Now, when the first ball completes its first revolution, the second ball will be on the second half of its round, and the third ball on the third part, and the fourth ball on the fourth and the fifth on the fifth, and the sixth on the sixth, and the seventh on the seventh, and the eighth on the eighth⁷. Thus while the eighth ball would have traversed its whole course the first ball would have made eight revolutions. Whilst those eight balls would be fulfilling their circular course, the wheel would revolve very frequently between those

¹ This sentence conforms to O'Farrelly's translation which fits the context like a glove. The contradiction in Power's translation is largely the result of scribal confusion with the numerals in this sentence. (JW)

² The period of the moon's rotation (as distinct from the lunar month), is known to be 27 days, 7 hours and 43 minutes. The 27 days referred to in the Tract compares favourably. (JW)

³ The above few sentences are based largely on O'Farrelly's interpretation. Power's translation is prone to be rather obscure in parts. (JW)

⁴ "The following illustration was given by Cleomedes, not by Ptolemy. See Cleomedes' *De Contemplatione Orbitum excelsorum Disputatio*; or, as it is also called somewhat oddly, *Circulorum Caelestium Conversione*. Cleomedes supposed ants, not balls, moving in the circular grooves. This is preserved in the Latin of Stabius, who has *formica*." (Close)

⁵ This is the potter's wheel that Cleomedes speaks of.

Close: "Stabius has for this *alii bathara*. The MS in the Bodlian Library (ms Ashmole 393) has *bachara*, and no *alii*. Stabius' reading is wrong; that of the Bodlian MS right."

⁶ "Cleomedes supposed his ants to be crawling in the concentric grooves with equal velocities." (Close)

⁷ "the eighth on the eighth"; – It is implied here by Cleomedes that the interval between the sphere of Saturn and that of the fixed stars is equal to the other intervals; a notion with which Messahalla's master, Ptolemy, would by no means agree." (Close)

revolutions from the east to the west of the world and those eight balls would very often begin their own travelling around.¹

And to enlighten the mind of the reader I have set down this diagram.

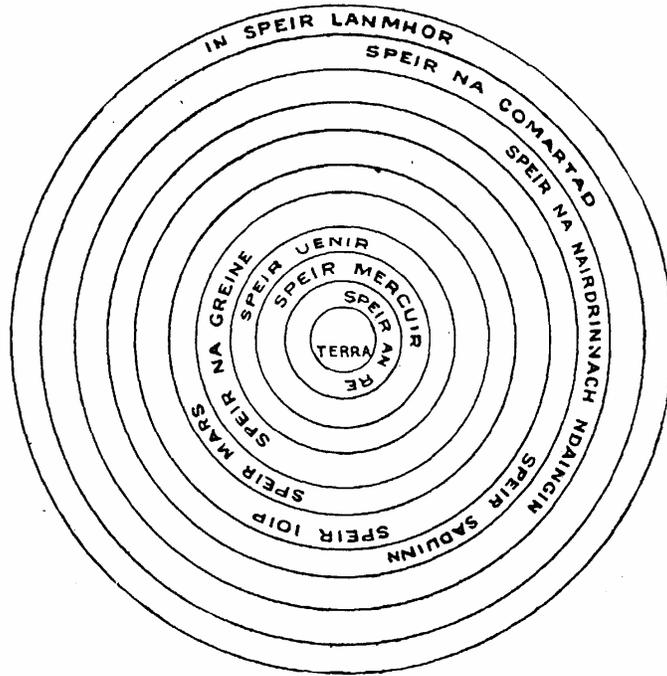


Figure 24

* * *

¹ I have modified Power's translation to conform with O'Farrelly's interpretation. It would appear that Power was unfamiliar with the analogy of Cleomedes. (JW).

30. SCIENDUM EST QUIA MAXIMA SPHAERA, ET CETERA.¹

Be it known unto you that the very great sphere² is the straight sphere. Ill-informed persons have given many erroneous opinions concerning it, for they declared that, since it is the highest and loftiest and swiftest of the spheres, it is the origin of the universe. It completes its course in a day and a night, and contains in itself three hundred and sixty degrees of the Zodiac, and the sphere of the fixed stars moves in a contrary direction to this from the west of the world to the east and is one hundred years travelling one degree.³ Each of the spheres of the planets completes its course according to its narrowness or wideness.

Moreover, the very great sphere, which surrounds all the other spheres on every side, controls them and causes them to revolve from the east of the world to the west; and this is the cause of night and day, light and darkness, and of the changes of the seasons, of spring and summer, autumn and winter.

Inside of this sphere everything is protected and controlled and set in motion, lest at anytime they might change their state or position or order, and this causes the planets to revolve so easily while the earth is immovable. For, if the earth were movable, day or night could not preserve their own course, as they do now, and the course of the planets and spheres of the firmament could not be determined, as they now are. There are no stars in that sphere. The ill-informed have said that it has life and that everything receives life from it; but I declare however that great its powers over everything I have mentioned, that it receives these powers from its own creator. As a proof that it is so - it is not known what work anybody performs until it has taken effect. Then, since we know every action that is effected by the very great sphere before it has been performed, those actions are performed by some other being, and are not of itself.⁴

* * *

¹ "This Chapter is not very close to Stabius' Chapter 19, in the early part; and in the latter part is not in Stabius at all." (Close)

² *Speir romor*.

³ O'Farrelley's translation has been incorporated here. Concerning the figure given for the rate of precession, Close recorded the following comment: " 'one hundred years', - This was Ptolemy's estimate founded on mistaken data. Albatani (d.929) pointed out that Ptolemy's estimate of the rate was considerably too small; he made it 1° in 66 years; much nearer the truth; but too large. The real rate of the relative movement of the equinoctial points and the fixed stars is 1° in 72 years. . . . Shah Cholgi, the Persian, fl. AD 1260, says that 1° in 70 years was adopted in his time; wonderfully near the truth".

⁴ The closing proposition follows a traditional scholastic line of thought; again suggesting a Dominican origin. (JW)

31. SECUNDA SPHAERA POST MAXIMAM SPHAERAM ETCETERA.¹

The Zodiac, i.e., the Sphere of the Signs², is the second sphere after the very great sphere, and is nearer the earth than the latter, and [the Zodiac] is also without stars, as I mentioned that the very great sphere was, and it moves from the east to the west of the world like the latter. The ancients imagined that there are nine spheres in all, and that it [the Zodiac] is one of the orbits of the very great sphere. Ptolemy refutes this theory in his own book, and says that he found a great difference between the very great sphere and the Zodiac as regards its zones and poles, for he found the north pole in the Zodiac twenty-four degrees higher than the same pole in the very great sphere, and he found the south pole of the Zodiac another twenty-four degrees under the same pole in the great sphere³. And the zones of this sphere are twenty-four degrees from each other in the top of the firmament.⁴ Therefore Ptolemy establishes ten spheres, and we refer to the ninth sphere when we say that the sun, or moon, or other planet is in a certain degree in the signs of that sphere.

The reason that these names; Aries, Taurus, Leo, etc., are applied to the signs of the Zodiac is because the constellations in the sphere of the stars opposite that portion of the Zodiac which is called Aries or Taurus correspond in shape and nature to the same animals we have here [below]; but there is no figure at all in the Zodiac, because as I have stated, there is no star in it.

The philosophers divided the Zodiac into twelve parts, and called each part a sign, according to the name or shape of the thing which is beneath that sign in the straight line in the sphere of the stars. Similarly, they divided the year into twelve parts according to those twelve signs of the sun, and called the course of the sun in each of the signs a “month”.

And the philosophers taught that the change of season occurs according to the course of the sun from sign to sign, and according to elevation or depression, for when the sun enters the first point of Aries⁵ an equinox occurs, i.e., equality of day and night, and then spring begins and does not depart until the sun is in [the last point of] Gemini; and when the sun enters Cancer, that is the beginning of summer. When it is there at the highest point of its sphere above, the sun heats the surface of the earth to a great extent, and when it arrives at

¹ Moderately close to the corresponding Chapter 20 in Stabius.

² “This name for the starless Second Sphere is unquestionably meant to convey that it is a sphere which carries the signs of the Zodiac (as distinct from the constellations of the same names), just as the Sphere of the Fixed Stars carries those stars along with itself in its rotation.” (Close)

³ “Messahalāh is in confusion on this matter. It is quite right that the circle of the Zodiac, or of the Signs, i.e., the ecliptic, is a great circle both of the Great Sphere and the Second Sphere; even taking the latter as Messahalāh does. It is also true that the poles of these two spheres are 24° apart. Ptolemy does not ‘refute’ the former by asserting the latter.” (Close)

⁴ The angular tilt of the earth’s axis of rotation with respect to that of its solar orbit is known to be 23° 27’ at present and decreasing at the rate of 28 seconds per century. Its value in the 14th century would have been very close to that quoted in the Tract. (JW)

⁵: “In Stabius the names of the Syrian months are here given; Nizar, Aiar, Haziran and so forth.” (Close)

the last point of Virgo, it brings the summer to an end. When it arrives at the last point of Libra, the second equinox occurs, and then autumn begins and does not depart until the sun is at the last point of Sagitarius. When it is in the last point of Capricorn, winter begins and continues until it is in the last point of Aries again, and then the spring begins again.

The reason that one winter is colder than another, and a winter wetter than another, and a winter drier than another and one summer hotter, and another drier than another, is because the sun is the cause of spring, summer, autumn and winter, and the other planets cause the same seasons.¹

When the summer of the sun occurs, and the other planets are in the sign of their own winter, there is a great deal of rain and cold in the summer; and when the winter of the sun occurs, and the other planets are in the signs which show their own summer, there is wind and little rain and cold in that winter especially. And similarly as regards the other seasons. The heat and cold, dryness and wetness of the four seasons of the year depend upon the movements of the planets in the signs of the Zodiac, as the Blessed Creator himself has ordained them.²

* * *

32. DICO QUOD SATURNUS PER QUATUOR ETCETERA.³

I declare, since Saturn has four motions, that it has four spheres in which it moves. The first motion [that of] the very great sphere from the east of the world to the west; the second motion, its own natural motion from the west of the world to the east, the third motion,⁴ the motion of the sphere in which it itself is fixed, and in which it moves in a direct line, or backwards, swiftly or slowly; the fourth motion, the motion of the eccentric sphere, and it is in that motion (lit. on that sphere) every planet is raised as high as possible from the earth, and is lowered as near as possible to the earth; and these are the four motions that all the planets have, except the sun, which has two spheres and two motions.

I will again describe those four spheres together with their motions themselves; and first I will make a figure of the very great sphere, and the figure of the earth in the middle of it, and I will place A in the east of it and B at the top of it and C in the west of it and D at the bottom of it, and thus is the motion of the very great sphere from A to B, from B to C, from C to D, and from D to A.

¹ “This is very curious!” (Close)

² Concerning this last paragraph, Close comments; “pretty close to the corresponding Chapter (21) in Stabius; but much better expressed”.

³ This Chapter is moderately close to the corresponding Chapter (22) in the Latin of Stabius.

⁴ The author is here referring to the action of the epicycle in Ptolemaic terminology. In what follows, it is designated as the fourth sphere (Fig 28), and the so-called ‘fourth motion’ relates to the third sphere (Fig 27). The order is arbitrary. (JW)

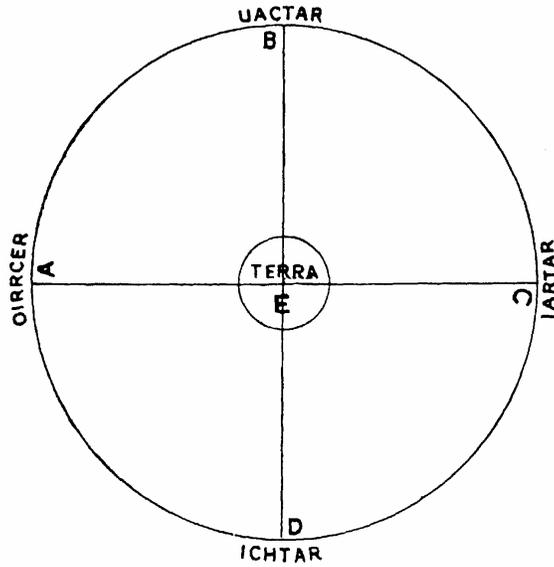


Figure 25

I make a figure (Fig 26) of the second sphere, which moves from the west of the world to the east, and which is under the very great sphere, and in the direct line beneath the Zodiac; and the Zodiac is situated obliquely, and the very great sphere is directly over our heads, because, as I mentioned, their poles and their pivot are far apart.

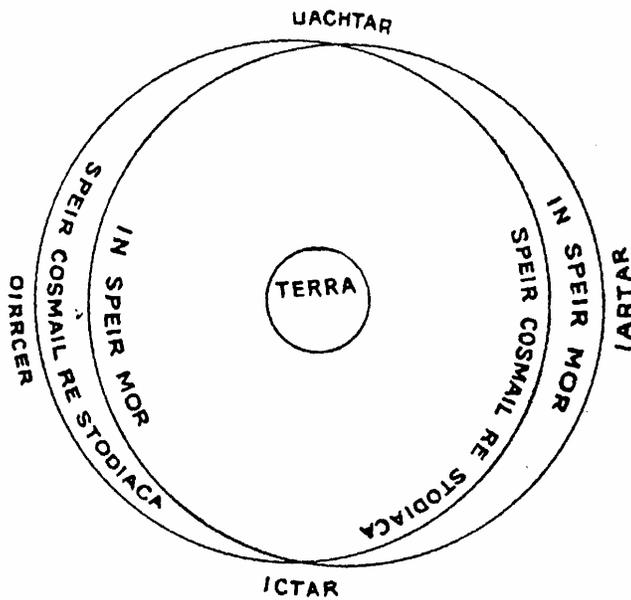


Figure 26

I will make a figure (*fig 27*) of the third sphere¹, the eccentric sphere, inside the two preceding spheres. The centre of this sphere is south of the centre of the earth by two and a half degrees, according to the measurement of the diameter of the sphere, and is divided into one hundred and twenty parts;² and this sphere is near the earth on one side, and distant from it on another.

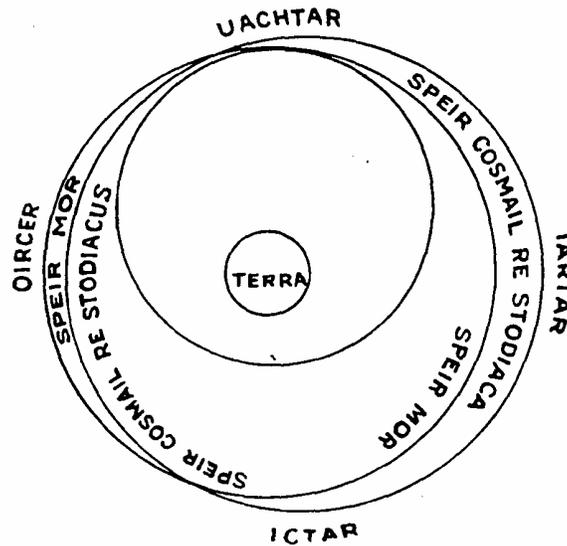


Figure 27

I will make a figure (*fig 28*) of the fourth sphere³ which confines firmly the body of the planet within itself, inside of the other three spheres.

¹ "i.e., the eccentric" (Close)

² "2½ degrees" – Ptolemy divided the diameter of the circle into 120 equal parts (Almag. I. 9, vc), It is 2½ of these parts which is here intended. Ptolemy himself, however, makes this 7.8 parts; not 2½ (Almag. X., 5, 297 near beginning). Clavius makes it 3.25 mins. Albatani and others also used these divisions of the diameter.

³ This sphere is the epicycle (Close)

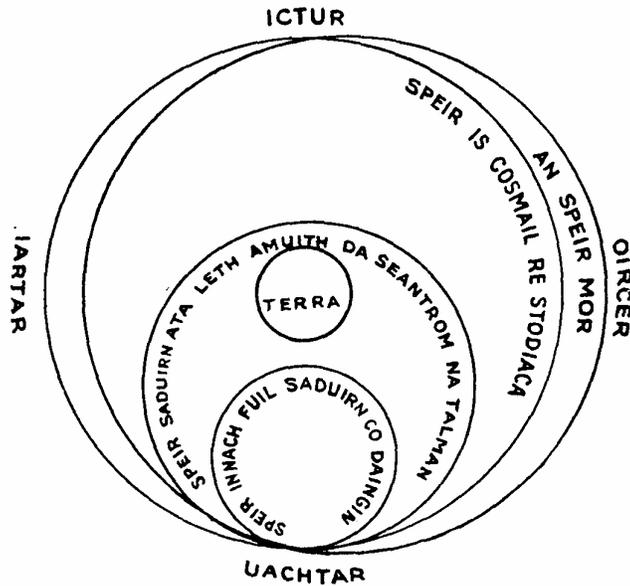


Figure 28

The centre of that planet¹ forms the centre of that sphere in which it is, and it moves from the west to the east of the world; and at the top of the eccentric sphere is the centre of those planets like a firm immovable nail in a sphere. It is not a straight course like that of an arrow that the planets have, but a circular natural course like that of a cartwheel, moving from the west of the world to the east, and if there was a nail in the upper rim of the cart [wheel]² moving from the west of the world to the east, whilst the nail would move downwards towards the earth, it would not move westwards or eastwards, and when it would reach the earth, it would incline its course from east to west; and when it would rise up from the earth it would not move westwards or eastwards, but when it would reach the extreme top, then it would move eastwards; and this is what causes the planets to perform a forward course at one time and a backward course at another, and a swift course at one time and a slow one at another.

* * *

¹ The Irish text uses the term *retlaine*, but it is clearly referring to the planet. It was not uncommon in earlier times to include the planets under the generic grouping of stars; the so-called *stellae errans* of the Classical world. (JW)

² Maxwell Close was rather critical of this analogy of epicycle motion, being at pains to point out its deficiency. I am inclined however, to look benignly upon its limitations, bearing in mind it is an attempt to concretise the apparent non-uniformity of planetary motion for the benefit of students seeking an elementary grasp of astronomy. (JW)

33. POSTQUAM SATURNI SPHAERA MOTUS, ETCETERA.¹

Having spoken of the sphere and motion of Saturn and the other planets, I shall now tell how they turn backwards, which is called “*retrogressio*,” i.e., a back-turning, i.e., when the planet turns back from Aries to Pisces.²

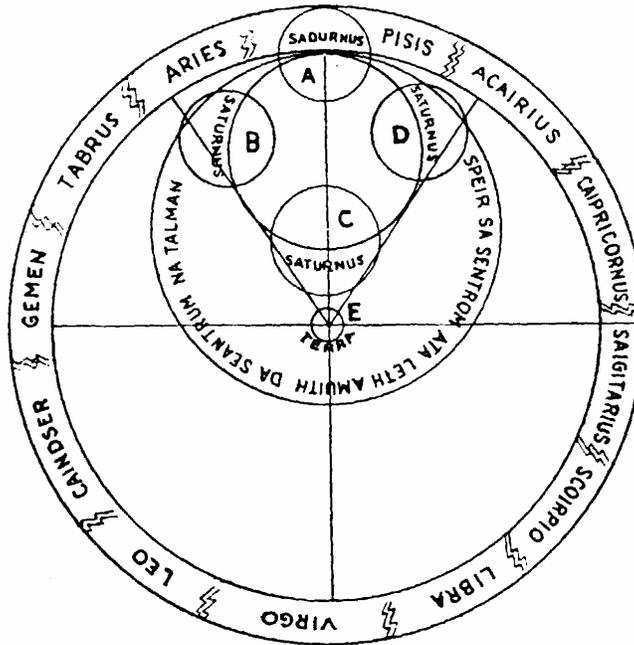


Figure 29

To explain that, I will make a figure of the two spheres of Saturn, and outside of them I will place the sphere of the signs and divide it into twelve parts, and then inside of it I will place the eccentric³ sphere of Saturn, and above at the top of it I will place the sphere in which the body of the planet is fixed⁴, and then I will place the earth in its own position with E in the middle of it and Saturn in four small circles around its own circumference. I will place the first of those small circles at the top of its own circle and a line through it between Aries and Pisces; the second circle in the first stopping place, with B in the middle of it; the third circle in the place where it turns back, with C in the middle of it; the fourth circle in the second stopping place with D in the middle of it, and I will draw three lines from the centre of the earth up through Saturn to the figure of the signs which are in the sphere of the fixed stars. Those lines represent the sight of the eyes up from the earth towards Saturn, and I will draw the vertical line up from the earth towards A, and thus when

¹ “This Chapter is moderately close to the corresponding Chapter (23) in Stabius.” (Close)

² The planet Saturn is known to have regressed from Aries to Pisces towards the end of the year 1350. This was the only occasion during the 14th century that a clear regression for these two signs took place. (JW)

³ Lit.; “(sphere) whose centre is outside the centre of the earth”.

⁴ i.e., the epicycle.

Saturn is in position A, it is in the beginning of Aries in the Zodiac, and its motion is eastwards full and direct, and when it has moved thus eastwards some degrees in Aries it inclines towards B, and when it arrives there it moves neither to the east nor west, and, therefore, that is its first halt, and when it departs from that position it moves back to D, and that is the place of its retrogression, and there it has a full direct motion from the east of the world to the west; and as it moves westwards, when it reaches position C, that is its second halting place, because there it moves neither to the east or the west. Whosoever would then look up from the middle of the earth he would find then in Pisces the same Saturn which was previously in Aries, and on its leaving D in the east it will mount by degrees again to A. That is the reason why the planets appear larger at one time than at another, because, as they make a retrogressive motion towards the earth, they appear at their largest.

All that I have said concerning spheres and motions and every other quality which Saturn possesses, ought to be understood with regard to Jupiter and Mars, since there is no difference between them in their course, or in their motion, or in their actions. The three planets that are above the sun, experience the same things, although they are not evident from the moon on account of the excessive speed of its eccentric sphere, because the sphere which holds the moon firmly moves eastwards, and when it turns on its backward course it moves westwards, and, therefore, that revolution is not evident although its other course and its halting are evident, because one day it moves twelve degrees and another it moves fourteen degrees.¹

* * *

Concerning the sphere of the fixed stars.

34. HAEC SPHAERA OCTAVO SITUATUR IN LOCO, ETCETERA.²

This sphere is situated at the eighth place in the firmament, and is formed after the pattern of Aries and Taurus and Gemini and the other signs of the Zodiac. The stars of that sphere move, with equal speeds and at fixed distances³ from each other at every season for ever and ever from the west of the world to the east, for they are not accelerated or retarded nor have they a direct course, nor a retrogressive motion like the wandering stars, and they spend a hundred years traversing one of the degrees of the great sphere.⁴

* * *

¹ “This paragraph is not in Stabius.” (Close)

² “This Chapter is not very close to Stabius’ Chapter 24; but it is better expressed.” (Close)

³ Minor ammdments to this sentence in Power’s translation have restored the intended meaning. (JW)

⁴ See the earlier footnote in Chapter 30 concerning the rate of relative movement of the equinoctial points. (JW)

35. AD HAEC¹ INDICANDA GEOMETRICA SUNT.²

To pursue this study, it is necessary to obtain geometrical arguments, in which we can believe without doubting. I will make then a figure of the earth, and I will place E in the centre of it, and I will describe another circle from the north of it to the south, and draw a straight line from the Arctic (Celestial) Pole to the Antarctic (Celestial) Pole through the centre and circumference of the earth, and place A at the zenith of the firmament, and B in the northern pole of the circle, and C down below it, and D in its south (celestial) pole.³

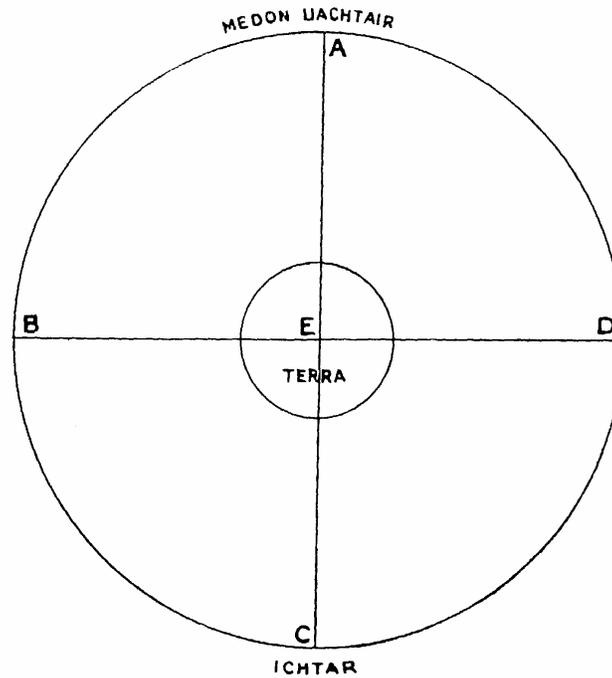


Figure 30

¹ “‘Haec’ clearly refers to something that went immediately before in the work from which this Chapter is taken. It does not refer to anything in the preceding Chapter 34. Can it be that it immediately followed what we have above in Chapter 7, in the work just referred to? Both chapters are non-Messahalic. This would be a most suitable continuation of Chapter 7.” (Close)

² “This Chapter is not in the Latin of Stabius.” (Close)

³ Details of the description are taken from O’Farrelly’s translation. (JW)

Therefore, whosoever being in position E (at the equator), should take the astrolabe in his hand - for with it will be obtained full certain knowledge of this matter - and placing his face along the middle line of the astrolabe which he holds suspended by a thread from his thumb, and beholding the Arctic (Celestial) Pole through the two holes of its two plates, would find that pole level with the earth; and if you travel three score six and two-thirds of a mile¹ from E to B and then place the astrolabe opposite the Arctic (Celestial) Pole, and look through it as you did before, you would find it has an elevation of one degree above the horizon² and one of the three hundred and sixty degrees of the astrolabe proves it to be so.



Sixteenth century astrolabe,
National Museum of Ireland.

Again, if you move another three score six and two-third miles from that towards B, and place the astrolabe opposite the same pole³, and look as before, you will find it has an elevation of two degrees,⁴ and so on, always, from E to B, for every three score six and two-thirds miles until one would reach B, one would find the same pole increasing in height by one degree. The amount of all those miles put together in accordance with the amount of the three hundred and sixty degrees⁵ which are in the circumference of the sphere of the earth, make 24,000 miles⁵, which is the circumference measurement, including the water and the land of the globe. And the *alkoterra*,⁶ i.e., the diameter of the earth's globe, is eight thousand miles⁷, and, accordingly, it is four thousand miles to the centre of the earth, and three thousand to every thousand of these is the extent that should be therein [i.e., in the circumference].⁸

¹ The MS Stowe B reads $66\frac{3}{4}$ miles. The Marsh MS has $66\frac{2}{3}$ miles which conforms with that mentioned later in the chapter as well as the calculation yielding 24,000 miles. (JW)

² *ceim ar airdi ann os cinn na talman*.

³ i.e., the celestial pole.

⁴ *da ceim ann ar airdi os a cinn*.

⁵ "Al Mamoun, the Khalif, who was patron of Messahalah, ordered the measurement of a degree on the earth's surface to be made near the Red Sea, and in Mesopotamia, which made the circumference of the earth to be 24,000 miles; but unfortunately, it is impossible to say what this means precisely, as the value of the cubit that was used is not certainly known". (Close)

The known values of the earth's circumference at the equator is 24,902 miles. (JW)

⁶ "This is Arabic for 'the diameter'. This shows that this chapter, at least, of those not in Stabius, is from an Arabian writer." (Close)

⁷ This figure also compares favourably with the known value for the mean diameter for the earth; 7,639 miles. In Classical times, Aristotle estimated the earth's circumference to be around 400,000 stadia, a figure almost twice the known value. A little later, Erastothenes of Cyrene (276BC) calculated it to be 250,000 stadia, (estimated to be approximately 24,662 miles). Posidonius (1st cent BC) also arrived at a similar value. It was not until the work of Willibrord van Roijen Snell in the late 17th century that a more precise value was arrived at. c.f. *Erastothenes Diameter of Earth: Appendix B*, in "Commentary on the Dreams of Scipio by Macrobius", ed., William Harris Stahl, Columbia Univ. Press, N.Y., 1990, p251-2. (JW)

⁸ This sentence is in conformity with O'Farrelly's translation. (JW)

"This making $\pi = 3$ is interesting; Archimedes having shown long before, that its value is between $3^{10/70}$ and $3^{10/71}$. Alfergani seems to have been aware of this; as he makes $\pi = 3^{1/7}$.

36. ANTIQUI LINEA AB ORIENTE AD OCCIDENTEM, ET CETERA. ¹

The ancients imagined a line through the middle of the earth directly from the east of it to the west co-incident with the equinoctial line, and they handed it down to us that that line is equidistant from the Arctic and the Antarctic Poles.

Between that line² and the Arctic Pole is the habitable part of the earth, although that entire portion is not habitable. No living thing on earth can exist from the same line to the Antarctic Pole, on account of the excessive heat. Because, since it is in the eccentric sphere that the body of the sun is borne around the earth, and since that sphere inclines towards that side, that side of the earth must necessarily be much hotter than any other, and the heat which is on that side scarcely exceeds the cold which is on the other side opposite it. Consequently, at the extreme northern portion of the earth, on account of the great distance of the sun from it, there is nothing but many dark clouds and much wind and rain, frost, snow and excessive cold. On that account that place is uninhabitable, and the part which is along the equinoctial line temperate.

The days and nights of the year are exactly of equal length in that place. The portion of the earth which is habitable extends from that line along the equinoctial as far as the uninhabitable district in the north. The ancients

The writer of this chapter agrees with the writer of 1 Kings VII, 23, and with the ancient Babylonians". (Close)

¹ This Chapter is not in the Latin of Stabius.

"After considerable search among numerous writers who mention this subject, I have not been able to find whence this chapter has been derived. Perhaps it may have been original with the writer, who was not Messahalla. . . .

The fact that this non-Messahallic Chapter carries the habitable region of the earth much more northward than was done under the usual scheme of Messahalla's time (given by Alfergani, etc.) seems to argue a later date for it, when geographical knowledge had increased. The same seems to be indicated by this scheme beginning at the equator, which was regarded in the common scheme as uninhabitable from excessive heat. . . .

The notion of the Seven Habitable Climata, or belts of latitude, existed already in the time of Hipparchus. The boundaries between the climates were the lines of latitude which the longest day of summer, midsummer day, had certain rather arbitrary chosen lengths. There were, at least in after times, different schemes for these Climates; some carrying the habitable part of the earth higher up northward than others. At first, the number of the Climates was seven. (Ptolemy's system of climates is outside the present matter. See Almag. II, 6). They were moreover, restricted to the northern side of the equator; it being supposed that, from the equator southwards, the earth was uninhabitable from heat. Messahalla himself thought this (see Ch. 26, supra). The writer of Chapter 14 thought so also, and the writer of the present chapter, whether the same person or not. Some, e.g., Cleomedes, thought it simply uninhabited, being inaccessible to man because of the intolerable heat of the equatorial zone which must be crossed in order to reach it. Poseidonius, however, thought that the neighbourhood of the equator should be temperate, on account of the sun's crossing it more quickly, when passing from one hemisphere to the other at the equinox. Our present writer agrees with this idea. In justice to him and to Messahalalah, as to their notion of the uninhabitability of the southern side of the earth from heat refer to Note above (Cha 28). He was led into this mistake, not through a sublime ignorance of the effect of latitude on climate, but by a certain other notion, which, though equally wrong, is much more excusable." (Close)

² I.e., The equator.

divided that portion into seven parts in all, from the east of the earth to the west, as this figure demonstrates.

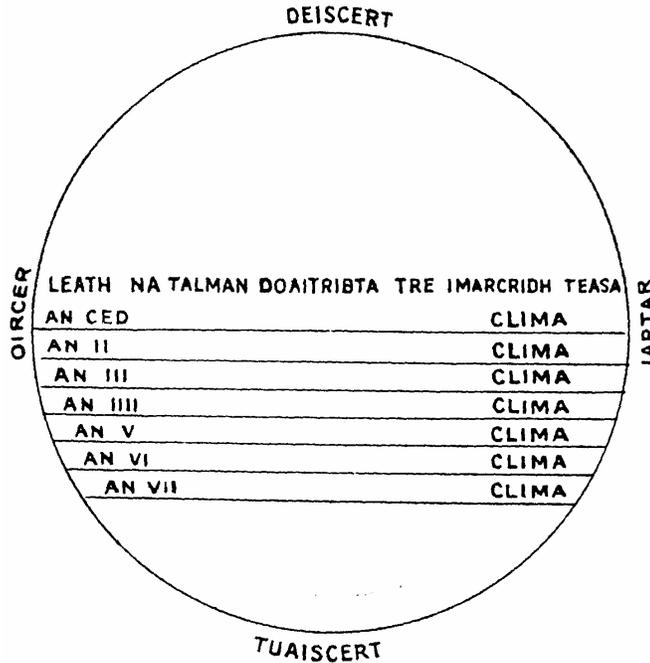


Figure 31¹

Concerning the nature of those lands:

From the line along the equinoctial begins the first zone as regards latitude, and extends in longitude, as I mentioned, from the east of the world to the west. And the whole day does not exceed twelve hours and two-thirds exactly twice a year, and is not shorter than eleven hours and one-third. Twice in the year the sun passes (directly) over the inhabitants of that region, i.e., when it moves from the south of the firmament to the north, and from thence to the south again; consequently, there are two summers in one year in that region. In that region, from north to south of it, the shadow never inclines.

The nature of the second zone:

The excessive amount of the sand of that region makes it too warm, because the heat of the sun penetrates the sand, and scorches and burns the surface of the earth; and when a high wind comes it collects the sand and forms hills and mountains from it and at another time scatters it. The inhabitants of that region

¹ This diagram is reproduced as it appears in the ITS publication. Clearly the scribe of ms Stowe B has made no attempt at a scale representation. (JW)
Close makes the following pertinent comment: "The original diagram has been drawn in accordance with Aristotle's idea that the South Pole is the uppermost point of the earth; *De Coelo*, Book II, Chap.2."

are black people called “Negroes,”¹ with curly hair. There is a great abundance of gold in that region, because the very great heat of the sun parches the surface of the earth. Not in the veins and hollows of the earth is the gold found, as are silver, tin and other metals, but on its surface. Day never exceeds thirteen hours, or is less than twelve hours in that region.²

The nature of the third zone:

The heat of these regions is less than that of the previous one because the sun is never directly above except for a short time in the summer solstice, and that climate is more temperate than either of those I have mentioned. The inhabitants of that region are of a swarthy colour, with curly hair and slender bodies, and the trees of their country do not grow to any height, and day does not exceed fourteen hours, and neither is it ever less than ten hours in that region.

The nature of the fourth zone:

The climate of this region is more temperate than that of the other regions I have mentioned, because they have no excessive cold or heat, and they abound and are enriched by the variety of exotic trees and many fruits of the earth, and the inhabitants of the first and second regions can dwell in it easily and without danger. The inhabitants of that region are of a yellow colour, between white and swarthy, they are intellectual and refined, with good memories and much wisdom; and in this country the greatest number of people of great knowledge and wisdom, generosity and physical strength have been. Also the water of that country tastes better than that of the others. Day never exceed fifteen hours, nor is less than nine hours, in that region.

The nature of the fifth zone:

Its heat is less, and its cold greater than that of the preceding region, and yet their trees are more numerous, and the fruit of their fields more excellent. The inhabitants of that country have medium-sized bodies their complexion is neutral,³ nearer to white than to swarthy, their wisdom is less and their life shorter, and they are wealthier than the people of the preceding climate. And daylight extends to sixteen hours, and diminishes to eight hours in that region.

¹ Ir. *fir gorma*, lit. ‘blue men’. Irish may not have had a then current term for the word Negro. It highly likely that the Irish author had never seen a Negro. Whatever the case, the term has remained in use. (JW)

² “The writer has here forgotten, with some others who have written on this subject, that (neglecting refraction and twilight, as is clearly intended) the sum of the length of the longest and the shortest days, at any one place, is 24 hours. For ‘below 12 hours’, read ‘below 11 hours’.” (Close)

One could not discount the possibility of a transcription error in this case, in view of the fact that this point is correctly addressed in the other zones. (JW).

³ It would appear from his assertion that their complexion is ‘neutral’ and their bodies ‘medium-sizes’, that the author identifies with this zone. (JW)

The nature of the sixth zone:

Its heat is less and its cold greater than that of the preceding regions, and the produce of its trees and fields is less than that of the preceding regions, on account of its coldness, and great is the snow and rain, and many are the clouds, wells, rivers, hills and mountains of that region. The inhabitants of that region have weak bodies, are of fair complexion, with smooth hair, while they are savage and uncouth. The longest day of that region is of seventeen hours duration, and the shortest day eight and a half.¹

The nature of the seventh zone is, lack of heat and excess of cold.

The inhabitants of that region are unintelligent and uncouth, with weak minds and brutish memories, and weak bodies, and smooth, fair, yellow hair; and if the inhabitants of this region went to the first or second region, or if the inhabitants of those regions came to this one, both of them would die on account of the change of climate.

Therefore, the fourth region is the most temperate, and is the best of them, all things considered, for the mildness of the heavens nurtures that region beyond all. The longest day in that region [i.e., the seventh] is eighteen hours, and the shortest six.²

* * *

Concerning the places where the whole year is one day and one night.

37. DUO IN TERRE LOCA ESSE NOVIMUS, ET CETERA.³

We know two places on the earth, one in the straight line under the Arctic Pole, the other in the straight line under the Antarctic Pole where the whole year is one day and one night, since six months are one day, and the other six months one night. Whosoever be at the extreme north of the earth in the place where the Arctic Pole would be, i.e., the axis of the north of the firmament in the straight line above him, would see the circle of the straight line which coincides with the circle of the signs around him, and thus would see the motion of the firmament like the motion of a quern; and thus when the sun enters the straight line in the first part of Aries, it rises in the east under the earth with reference to that place I mentioned, and causes day there, revolving around it: like a quern⁴, and turns from east to south and from south to west, and from west to north and from north again to the east, and [the sun] continues thus constantly revolving in the same degree until it arrives at

¹ Close: "For 'eight and a half' read 'seven'." C.f., earlier footnote for Zone 2.

² "These old systems of seven habitable climates were invented by persons living in more southern latitudes than ours, and inadvertently adopted by northerners, who did not perceive all that was implied therein." (Close)

³ This Chapter is not in the Latin of Stabuis.

⁴ "This simile is in Alfergani, and Albatani also." (Close)

Cancer. Then being in the highest degree it can possibly reach, over that place, it divides that long day into two equal parts, and from that gradually sinks until it comes to the end of the day, when it deprives the aforesaid place of its light. And thus there is day in that place, from the middle of the month of March until the middle of the month of September.

When the sun enters the first point of Libra, night begins to darken the same place, and the sun is then moving in a circuit, like a quern,¹ sinking gradually underneath the earth, until he enters the first point of Capricorn; beyond that it cannot sink, and then occurs the middle of that great night. At that time the sun begins to rise gradually from that place, until it enters the first point of Aries, and day begins again in the place I mentioned. Consequently, there is one long night in that place from the middle of September until the middle of March.

Similarly, whosoever would be in the south of the earth in the place where the Antarctic Pole would be, i.e., with the axis of the firmament directly overhead, would see the circle of the straight line turning like a quern overhead; and when the sun would enter the straight line in the first point of Libra, it would rise in the east under the earth with reference to a person who would be in the place that I mentioned, and day would begin with reference to him, and the sun would revolve like a quern from east to north, and from north to west, and from west to south, and the south to the east of the firmament.

Thus, it continues ever revolving without sinking, with reference to the place I mentioned, until it enters the first point of Capricorn; and when it has arrived at that highest point it can reach, it divides that long day into two parts and continues gradually sinking until it enters the last point of Pisces. It brings the day to a close then, the day which lasts from the middle of September until the middle of March. Then, when the sun enters the first point of Aries, night begins to begins darken the aforementioned place and then the sun keeps revolving and sinking gradually under the earth, until it enters the first point of Cancer, so that it cannot be lower with reference to that place, and then occurs the middle of that great night. The sun continues rising by degrees until it enters the first point of Libra, and the same long day begins again; and the night I described lasts from the middle of March until the middle of September.

* * *

¹ “ ‘like a quern’ – This is not so suitable here as above. Although it is in the ms in the Royal Irish Academy, it is not in that in Marsh’s Library.” (Close)

Concerning the winds; what they are, and whence they come.

38. ASSERUNT ANTIQUI PHILOSOPHI, ETCETERA.¹

Although the old philosophers say that Eurus is warm and dry, and Zephyrus warm and wet, and that Boreas is cold and dry, and Auster cold and wet, some of the doctors declare that neither Zephyrus nor Auster are so, but that Zephyrus is cold and wet, and Auster warm and wet; nor do I know whether they said so with reference to the general nature of the winds, or with reference to the nature of the winds in certain countries, since, we perceive a difference in the winds in various countries, because Eurus and Zephyrus are wet in some countries, and dry in others.² However, I shall relate the generalities concerning the nature of all the winds.

When the air has been heated by the sun it expands and becoming extended, dilates, and a black dark vapour rises from the sea up into the air and is converted into a cloud above, and, when that mist comes in contact with the cold air above, it suddenly contracts, which causes it to flow and dissolve, and converts it into rain. Moreover, when that sea vapour and the air come in contact with each other above in the warm dry atmosphere, and both together are drawn up to the frost region or to the domain of cold, they there become contracted and remain in the atmosphere. It is the nature of the warm air and that of the cold region [to be] opposed to each other, and they do not endure to remain in the same place, and, consequently, the [cold] space drives out the air, and being continually expelled, it runs from place to place setting the atmosphere in motion. That motion of the air is the wind, and the greater the cause whence the motion arises, the greater the wind.

Another cause of wind: When a battle or conflict is being fought by large hosts and vast troops, with the movements and panting of the men, some of them fleeing and others in pursuit, the rarefied air flies before them, and raises wind.

If you wish to prove clearly what we have said concerning the rising of the wind into the cold air after it has been heated, take a basin and put water into it to a depth of two or three inches, and place an empty glass vessel in it, and leave it there during the night until morning in some cool place; and in the morning you will find that vessel full of cold condensed air. Turn it mouth downwards in the water which is in the basin, and place them both in some place exposed to the heat of the sun, when it has risen; and when the condensed air in the glass becomes heated, it expands and dilates, and spreads and seeks a larger space, and since it has no way of escape except through the mouth of the vessel down into the water, it goes down into the water, and lifts it up to the mouth of the basin. It appears then like the full tide, gradually

¹ “This Chapter is like a free paraphrase of the corresponding Chapter (25) in Stabius. It is founded on Aristotle’s *Meteorologica*, Lib.I.” (Close)

² There is a hint of apology in the introduction of the ‘four winds’ of the Classical tradition. It is clear that the author perceives the traditional characters of these to be ill-suited to the Irish climate. These Mediterranean weather patterns would have been in marked contrast to the Irish experience. The fact that the ‘four winds’ are included at all is probably a testimony to the esteem in which Aristotle was held during the Middle Ages. (JW)

growing until, sometimes, it overflows the basin. It is that which proves that the air which was in the vessel we have mentioned, increases and expands. Leave it so again until the following night, and as the heat of the day departs, and the cold of the night comes, that cold will collect the air that was in the vessel into the same vessel again, and will condense it there and the water will subside into its own place again. Now, since this small volume of air has expanded so much, it is certain that the entire air, or a part of it, increases greatly in its own sphere.

* * *

Concerning the clouds, thunder, rain and lightning.

39. SOL [CURRIT SUPER] MARIA ET FLUMINA ET LOCA, ETCETERA.¹

The sun draws from the sea and from rivers and other wet places, vapours and mists which, owing to their thinness, are invisible except in the morning and evening. And when they are drawn up into the hot air, they are scattered and spread and mingled with the air, since they are of the same nature. On the other hand, when are drawn up into the cold air, they become compressed and contracted within themselves and they are converted into clouds, and since it is the nature of like things to approach each other, as the rivers enter the sea so do the lesser of these clouds approach the larger clouds since they are lighter and can move more readily. And they become one large dark mass, and since that mass is warm by nature, and the cold air surrounds it, they are opposed, and contend with each other.

When the air is the stronger, and overcomes the cloud, it binds and condenses its borders, and converts it into snow. Consequently, when the heat is inside in the cloud, and it is surrounded by the cold without, with the cloud freezing and hardening around it, it would seek, according to its nature, a place where it could extend and dilate and spread; and since the dense cloud does not suffer it to do so, the heat shakes it powerfully, and it (the cloud) breaks, and a great and terrible sound, called thunder, results from that breaking, and with the strength of the force by which that rupture is caused, thunder-bolts and lightning result from that rupture, and small fragments of that cloud fall, striking and breaking against each other. As they descend, they break each other again into small pieces, and when they come in contact with the part of the atmosphere nearest the earth, the heat of that place removes their jagged points, and renders them spherical, and the hailstones fall, and the small drops of rain that mingle with the snow come from the part which it loses as it melts.

The greater the above mentioned heat and cold, the greater the opposition between them, and as the opposition is increased, the thunder and lightning which results from them is increased. The part of the cloud which does not fall to the earth spreads throughout the atmosphere, and is converted into

¹ "This chapter is moderately close to Stabius' Chapter 26. It is founded upon Aristotle's *Meteorologica*, Lib.II." (Close)

lightning. The part of the lightning which comes to earth splits hills and mountains, and penetrating the earth, kills men and cattle.

As a proof that thunder results from the contrariety I mentioned, the philosophers have cited an example: When a green leaf is put upon fire, before it burns, when the heat comes in contact with it, it breaks with a sound. In the same way, when red [hot] iron is put into water, the contrariety of these two things draws a tremendous noise from them. Then since the contrariety of small bodies produces this noise, large bodies ought to produce a great noise.

There are more thunder, lightning and thunderbolts in spring and autumn, than in the other seasons, because these two seasons occur between the warm summer and the cold winter. The cloud which the blowing of the wind draws up from the earth into the cold, wet, thin attenuated air, without heat or dryness, except what is contained in the clouds themselves, possess no contrariety.

The heavy part which is contained in those clouds separates from them in drops, and is converted into rain, and when the cloud meets the warm air, it (the air) rarefies it and converts it back into air, and through the disagreement due to the contrariety of the heat and cold, dryness and wetness of that air, it is changed into large black clouds, and those black clouds are changed into heavy rain; and sometimes the same substance is converted into large drops of rain and great hailstones, which occur most frequently in spring and autumn. And when they occur in the summer, on account of that season possessing so much of the contrariety I mentioned, compared to the other seasons, the tempest is greater then. When a great wind accompanies that tempest, it gathers the clouds together up in the sky, and binds them, and makes them assume different shapes, and ill-informed people think that they are dragons. We perceive the dust of the earth being whirled around by the wind in the same way.

Although the thunder and lightning are produced simultaneously, the lightning is seen before the thunder is heard¹. The reason of that is that the eye sees what is near it and is distant from it in the same way, for it does not perceive the earth any sooner than it does the stars that are most distant from it in the firmament. That is not the case with the hearing, for one hears the sound that is near sooner than the sound which is distant; and in explaining that, the doctors compared the sense of hearing to a quern, for if there were an ear in the opening of the quern, it would hear everything near to it and distant from it indiscriminately, because the sense hearing is like air, which is a thin, subtle body, the motion of which is greater, smoother, and swifter than that of water.

When some disruption, or striking, or other noise occurs in the air, the air which is nearest that noise propels the sound away from it, towards the other parts of the air, until finally it enters the ear, and passes from the ear to the

¹ “It seems to be implied above (*earlier in this Chapter*) that the thunder is produced before the lightning. In the place in the *Meteorologica*, here in view, Aristotle distinctly states that this is so. Our present author does not do this here; indeed the succeeding context is rather the other way.” (Close)

brain, which distinguishes between the greatest and the least, and between the gentlest and the loudest noise.

In the same way, they compared the sense of sight to a trumpet which has a narrow end, and the further from the end it is the broader it becomes, and thus the sight of the eye passes through the tubular vein from the brain to the pupils of the eyes, and there has a narrow end like a trumpet, and it widens out until it meets the object which it beholds, and turns in again, carrying the shape form, and colour of that object with it to the brain.

* * *

Concerning animate, growing objects, destitute of sensation.

40. UNIVERSA ANIMATA INSENSIBILIA, ETCETERA.¹

Every thing which has life, and is destitute of sensation, can grow of itself, for we perceive many kinds of trees on which fruit grows of itself in the woods and hills, although the fruit of trees which human hands plant is more carefully and better cultivated than they. No tree in the world can grow except in its own natural place and climate. It is the seed of objects which have vegetable life and are without sensation, which gives them material generation because God, who made them, desired that they should contain the power of propagation whence would grow for ever in succession their own like corresponding kind; and thus when that seed falls to the earth, it becomes swollen from the wet rain falling upon it.

It is the nature of water to penetrate every body, except an impenetrable one, and the sun having heated that seed, draws its moisture out of it, because it is the nature of the sun to draw up every moisture, and then there grows from that grain, after its being heated and moistened, the natural growth which was, contained in its hidden powers within it, i.e., the germ of a plant like unto the plant from which it originally sprang; and the earth is ever supplying it with moisture in place of the moisture which the sun draws from it, and then a force is generated from those two things² called “vegetative life³,” and veins grow down out of it, [the plant] called roots, through which it draws to itself the nutriment of the soil. When the sun draws [up] this moisture, it draws with it the hidden force, and from it are created boughs, foliage, blossoms and fruit, and it continues ever thus growing, until it ceases to grow, and the fruit which is upon it is its seed, and is the germ of a similar plant again.

There are three kinds of growing things [i.e., plants]: some of them lose their foliage in winter and it comes on them again in summer. The second kind, which does not lose its foliage, either in winter or summer. The third kind

¹ This differs a good deal from the corresponding Chapter (27) in Stabius. It is apparently written under the influence of Aristotle's *De Plantis*.

² “virtues”, O'Farrelly.

³ Ir.; *ainim*, – ‘soul’.

dies, except for one thing, in winter, and from that seed a similar one grows in summer. The great master of philosophers, i.e., Aristotle, says that objects with growth and devoid of sensation are of three kinds: -
.....¹

* * *

¹ “The rest is illegible.” (O’Farrelly). “But scarcely a full page has thus been lost.” (Close)