

THE SPHERE OF SACROBOSCO

An early 13th century treatise on astronomy, by Iohannes de Sacrobosco.

Translated by Lynn Thorndike, 1949.

PROEMIUM

CONTENTS OF THE FOUR CHAPTERS. -- The treatise on the sphere we divide into four chapters, telling,

- **first**, what a sphere is, what its center is, what the axis of a sphere is, what the pole of the world is, how many spheres there are, and what the shape of the world is.
- **In the second** we give information concerning the circles of which this material sphere is composed and that supercelestial one, of which this is the image, is understood to be composed.
- **In the third** we talk about the rising and setting of the signs, and the diversity of days and nights which happens to those inhabiting diverse localities, and the division into climes.
- **In the fourth** the matter concerns the circles and motions of the planets, and the causes of eclipses.

CHAPTER ONE

SPHERE DEFINED. -- A sphere is thus described by Euclid: A sphere is the transit of the circumference of a half-circle upon a fixed diameter until it revolves back to its original position. That is, a sphere is such a round and solid body as is described by the revolution of a semicircular arc.

By Theodosius a sphere is described thus: A sphere is a solid body contained within a single surface, in the middle of which there is a point from which all straight lines drawn to the circumference are equal, and that point is called the "center of the sphere." Moreover, a straight line passing through the center of the sphere, with its ends touching the circumference in opposite directions, is called the "axis of the sphere." And the two ends of the axis are called the "poles of the world."

SPHERE DIVIDED. -- The sphere is divided in two ways, by substance and by accident. By substance it is divided into the ninth sphere, which is called the "first moved" or the *primum mobile*; and the sphere of the fixed stars, which is named the "firmament"; and the seven spheres of the seven planets, of which some are larger, some smaller, according as they the more approach, or recede from, the firmament. Wherefore, among them the sphere of Saturn is the largest, the sphere of the moon the smallest, as is shown in the accompanying figure.

By accident the sphere is divided into the sphere right and the sphere oblique. For those are said to have the sphere right who dwell at the equator, if anyone can live there. And it is called "right" because neither pole is elevated more for them than the other, or because their horizon intersects the equinoctial circle and is intersected by it at spherical right angles. Those are said to have the sphere oblique who live this side of the equator or beyond it. For to them one pole is always raised above the horizon, and the other is always depressed below it. Or it is because their artificial horizon intersects the equinoctial at oblique and unequal angles.

THE FOUR ELEMENTS. -- The machine of the universe is divided into two, the ethereal and the elementary region. The elementary region, existing subject to continual alteration, is divided into four. For there is earth, placed, as it were, as the center in the middle of all, about which is water, about water air, about air fire, which is pure and not turbid there and reaches to the sphere of the moon, as Aristotle says in his book of *Meteorology*. For so God, the glorious and sublime, disposed. And these are called the "four elements" which are in turn by themselves altered, corrupted and regenerated. The elements are also simple bodies which cannot be subdivided into parts of diverse forms and from whose commixture are produced various species of generated things. Three of them, in turn, surround the earth on all sides spherically, except in so far as the dry land stays the sea's tide to protect the life of animate beings. All, too, are mobile except earth, which, as the center of the world, by its weight in every direction equally

avoiding the great motion of the extremes, as a round body occupies the middle of the sphere.

THE HEAVENS. -- Around the elementary region revolves with continuous circular motion the ethereal, which is lucid and immune from all variation in its immutable essence. And it is called "Fifth Essence" by the philosophers. Of which there are nine spheres, as we have just said: namely, of the moon, Mercury, Venus, the sun, Mars, Jupiter, Saturn, the fixed stars, and the last heaven. Each of these spheres incloses its inferior spherically.

THEIR MOVEMENTS. -- And of these there are two movements. One is of the last heaven on the two extremities of its axis, the Arctic and Antarctic poles, from east through west to east again, which the equinoctial circle divides through the middle. Then there is another movement, oblique to this and in the opposite direction, of the inferior spheres on their axes, distant from the former by 23 degrees. But the first movement carries all the others with it in its rush about the earth once within a day and night, although they strive against it, as in the case of the eighth sphere one degree in a hundred years. This second movement is divided through the middle by the zodiac, under which each of the seven planets has its own sphere, in which it is borne by its own motion, contrary to the movement of the sky, and completes it in varying spaces of time -- in the case of Saturn in thirty years, Jupiter in twelve years, Mars in two, the sun in three hundred and sixty-five days and six hours, Venus and Mercury about the same, the moon in twenty-seven days and eight hours.

REVOLUTION OF THE HEAVENS FROM EAST TO WEST. -- That the sky revolves from east to west is signified by the fact that the stars, which rise in the east, mount gradually and successively until they reach mid-sky and are always at the same distance apart, and, thus maintaining their relative positions. they move toward their setting continuously and uniformly. Another indication is that the stars near the North Pole, which never set for us, move continuously and uniformly, describing their circles about the pole, and are always equally near or far from one another. Therefore, from those two continuous movements of the stars, both those that set and those which do not, it is clear that the firmament is moved from east to west.

THE HEAVENS SPHERICAL. -- There are three reasons why the sky is round: likeness, convenience, and necessity. Likeness, because the sensible world is made in the likeness of the archetype, in which there is neither end nor beginning; wherefore, in likeness to it the sensible world has a round shape, in which beginning or end cannot be distinguished. Convenience, because of all isoperimetric bodies the sphere is the largest and of all shapes the round is most capacious. Since largest and round, therefore the most capacious. Wherefore, since the world is all-containing, this shape was useful and convenient for it. Necessity, because if the world were of other form than round -- say, trilateral, quadrilateral, or many-sided -- it would follow that some space would be vacant and some body without a place, both of which are false, as is clear in the case of angles projecting and revolved.

A FURTHER PROOF. -- Also, as Alfraganus says, if the sky were flat, one part of it would be nearer to us than another, namely, that which is directly overhead. So when a star was there, it would be closer to us than when rising or setting. But those things which are closer to us seem larger. So the sun when in mid-sky should look larger than when rising or setting, whereas the opposite is the case; for the sun or another star looks bigger in the east or west than in mid-sky. But, since this is not really so, the reason for its seeming so is that in winter and the rainy season vapors rise between us and the sun or other star. And, since those vapors are diaphanous, they scatter our visual rays so that they do not apprehend the object in its true size, just as is the case with a penny dropped into a depth of limpid water, which appears larger than it actually is because of a like diffusion of rays.

THE EARTH A SPHERE. -- That the earth, too, is round is shown thus. The signs and stars do not rise and set the same for all men everywhere but rise and set sooner for those in the east than for those in the west; and of this there is no other cause than the bulge of the earth. Moreover, celestial phenomena evidence that they rise sooner for Orientals than for westerners. For one and the same eclipse of the moon which appears to us in the first hour of the night appears to Orientals about the third hour of the night, which proves that they had night and sunset before we did, of which setting the bulge of the earth is the cause.

FURTHER PROOFS OF THIS. -- That the earth also has a bulge from north to south and vice versa is shown thus: To those living toward the north, certain stars are always visible, namely, those near the North Pole, while others which are near the South Pole are always concealed from them. If, then, anyone should proceed from the north southward, he might go so far that the stars which formerly were always visible to him now would tend toward their setting. And the farther south he went, the more they would be moved toward their setting. Again, that same man now could see stars which formerly had always been hidden from him. And the reverse would happen to anyone going from the south northward. The cause of this is simply the bulge of the earth. Again, if the earth were flat from

east to west, the stars would rise as soon for westerners as for Orientals. which is false. Also, if the earth were flat from north to south and vice versa, the stars which were always visible to anyone would continue to be so wherever he went, which is false. But it seems flat to human sight because it is so extensive.

SURFACE OF THE SEA SPHERICAL. -- That the water has a bulge and is approximately round is shown thus: Let a signal be set up on the seacoast and a ship leave port and sail away so far that the eye of a person standing at the foot of the mast can no longer discern the signal. Yet if the ship is stopped, the eye of the same person, if he has climbed to the top of the mast, will see the signal clearly. Yet the eye of a person at the bottom of the mast ought to see the signal better than he who is at the top, as is shown by drawing straight lines from both to the signal. And there is no other explanation of this thing than the bulge of the water. For all other impediments are excluded, such as clouds and rising vapors.

Also, since water is a homogeneous body, the whole will act the same as its parts. But parts of water, as happens in the case of little drops and dew on herbs, naturally seek a round shape. Therefore, the whole, of which they are parts, will do so.

THE EARTH CENTRAL. -- That the earth is in the middle of the firmament is shown thus. To persons on the earth's surface the stars appear of the same size whether they are in mid-sky or just rising or about to set, and this is because the earth is equally distant from them. For if the earth were nearer to the firmament in one direction than in another, a person at that point of the earth's surface which was nearer to the firmament would not see half of the heavens. But this is contrary to Ptolemy and all the philosophers, who say that, wherever man lives, six signs rise and six signs set, and half of the heavens is always visible and half hid from him.

AND A MERE POINT IN THE UNIVERSE. -- That same consideration is a sign that the earth is as a center and point with respect to the firmament, since, if the earth were of any size compared with the firmament, it would not be possible to see half the heavens. Also, suppose a plane passed through the center of the earth, dividing it and the firmament into equal halves. An eye at the earth's center would see half the sky, and one on the earth's surface would see the same half. From which it is inferred that the magnitude of the earth from surface to center is inappreciable and, consequently, that the magnitude of the entire earth is inappreciable compared to the firmament. Also Alfraganus says that the least of the fixed stars which we can see is larger than the whole earth. But that star, compared with the firmament, is a mere point. Much more so is the earth, which is smaller than it.

THE EARTH IMMOBILE. -- That the earth is held immobile in the midst of all, although it is the heaviest, seems explicable thus. Every heavy thing tends toward the center. Now the center is a point in the middle of the firmament. Therefore, the earth, since it is heaviest, naturally tends toward that point. Also, whatever is moved from the middle toward the circumference ascends. Therefore, if the earth were moved from the middle toward the circumference, it would be ascending, which is impossible.

MEASURING THE EARTH'S CIRCUMFERENCE. -- The total girth of the 700 stades for each of the 360 parts of the zodiac (sic). For let one take earth by the authority of the philosophers Ambrose, Theodosius, and Eratosthenes is defined as comprising 252,000 stades, which is allowing an astrolabe on a clear starry night and, sighting the pole through both apertures in the indicator, [1] note the number of degrees where it is. Then let our measurer of the cosmos proceed directly north until on another clear night, observing the pole as before, the indicator stands a degree higher. After this let the extent of his travel be measured, and it will be found to be 700 stades. Then, allowing this many stades for each of 360 degrees, the girth of the earth is found.

AND DIAMETER. -- From these data the diameter of the earth can be found thus by the rule for the circle and diameter. Subtract the twenty-second part from the circuit of the whole earth, and a third of the remainder -- that is, 80, 181 stades and a half and third part of one stade -- will be the diameter or thickness of the terrestrial ball.

CHAPTER TWO

OF THE CIRCLES AND THEIR NAMES

CELESTIAL CIRCLES. -- Of these circles some are larger, some smaller, as sense shows. For a great circle in the sphere is one which, described on the surface of the sphere about its center, divides the sphere into two equal parts, while a small circle is one which, described on the surface of the sphere, divides it not into two equal but into two unequal portions.

THE EQUINOCTIAL. -- Of the great circles we must first mention the equinoctial. The equinoctial is a circle dividing the sphere into two equal parts and equidistant at its every point from either pole. And it is called "equinoctial" because, when the sun crosses it, which happens twice a year, namely, in the beginning of Aries and in the beginning of Libra, there is equinox the world over. Wherefore it is termed the "equator of day and night," because it makes the artificial day equal to the night. And 'tis called the "belt of the first movement."

THE TWO MOVEMENTS AGAIN. -- Be it understood that the "first movement" means the movement of the *primum mobile*, that is, of the ninth sphere or last heaven, which movement is from east through west back to east again, which also is called "rational motion" from resemblance to the rational motion in the microcosm, that is, in man, when thought goes from the Creator through creatures to the Creator and there rests.

The second movement is of the firmament and planets contrary to this, from west through east back to west again, which movement is called "irrational" or "sensual" from resemblance to the movement of the microcosm from things corruptible to the Creator and back again to things corruptible.

THE NORTH AND SOUTH POLES. -- 'Tis called the "belt of the first movement" because it divides the *primum mobile* or ninth sphere into two equal parts and is itself equally distant from the poles of the world. It is to be noted that the pole which always is visible to us is called "septentrional," "arctic," or "boreal." "Septentrional" is from *septentrio*, that is, from Ursa Minor, which is derived from *septem* and *trion*, meaning "ox," because the seven stars in Ursa move slowly, since they are near the pole. Or those seven stars are called *septentriones* as if *septem teriones*, because they tread the parts about the pole. "Arctic" is derived from *arthos*, which is Ursa Major, for 'tis near Ursa Major. It is called "boreal" because it is where the wind Boreas comes from. The opposite pole is called "Antarctic" as opposed to "Arctic." It also is called "meridional" because it is to the south, and it is called "austral" because it is where the wind Auster comes from. The two fixed points in the firmament are called the "poles of the world" because they terminate the axis of the sphere and the world revolves on them. One of these poles is always visible to us, the other always hidden. Whence Virgil:

This vertex is ever above us, but that
Dark Styx and deep Manes hold beneath our feet. [2]

THE ZODIAC. -- There is another circle in the sphere which intersects the equinoctial and is intersected by it into two equal parts. One half of it tips toward the north, the other toward the south. That circle is called "zodiac" from *zoe*, meaning "life," because all life in inferior things depends on the movement of the planets beneath it. Or it is derived from *zodias*, which means "animal," because, since it is divided into twelve equal parts, each part is called a sign and has its particular name from the name of some animal, because of some property characteristic of it and of the animal, or because of the arrangement of the fixed stars there in the outline of that kind of animal. That circle in Latin is called *signifer* because it bears the "signs" or because it is divided into them. By Aristotle in *On Generation and Corruption* it is called the "oblique circle," where he says that, according to the access and recess of the sun in the oblique circle, are produced generations and corruptions in things below.

THE TWELVE SIGNS. -- The names, order, and number of the signs are set forth in these lines:

There are Aries, Taurus, Gemini, Cancer, Leo, Virgo,
Libra and Scorpio, Architenens, Caper, Amphora, Pisces.

Moreover, each sign is divided into 30 degrees, whence it is clear that in the entire zodiac there are 360 degrees. Also, according to astronomers, each degree is divided into 60 minutes, each minute into 60 seconds. each second into 60 thirds, and so on. And as the zodiac is divided by astronomers, so each circle in the sphere, whether great or small, is divided into similar parts.

While every circle in the sphere except the zodiac is understood to be a line or circumference, the zodiac alone is understood to be a surface, 12 degrees wide of degrees such as we have just mentioned. Wherefore. it is clear that certain persons in astrology lie who say that the signs are squares, unless they misuse this term and consider square and quadrangle the same. For each sign is 30 degrees in longitude, 12 in latitude.

THE ECLIPTIC. -- The line dividing the zodiac in its circuit, so that on one side it leaves 6 degrees and on the other side another 6, is called the "ecliptic," since when sun and moon are on that line there occurs an eclipse of sun or moon. The sun always moves beneath the ecliptic, but all the other planets decline toward north or south; sometimes, however, they are beneath the ecliptic. The part of the zodiac which slants away from the equinoctial to the north is

called "northern" or "boreal" or "Arctic," and those six signs which extend from the beginning of Aries to the end of Virgo are called "northern." The other part of the zodiac which tips from the equinoctial toward the south is called "meridional" or "austral," and the six signs from the beginning of Libra to the end of Pisces are called "meridional" or "austral."

EXTENDED USES OF "SIGN." -- When it is said that the sun is in Aries or in another sign, it should be understood that *in* is taken for *beneath* according as we now accept sign. In another meaning a sign is called a "pyramid," whose quadrilateral base is that surface which we call a "sign," while its apex is at the center of the earth. And in this sense we may properly say that the planets are *in* signs. "Sign" may be used in a third way as produced by six circles passing through the poles of the zodiac and through the beginnings of the twelve signs. Those six circles divide the entire surface of the sphere into twelve parts, wide in the middle but narrower toward the poles, and each such part is called a "sign" and has a particular name from the name of that sign which is intercepted between its two lines. And according to this usage stars which are near the poles are said to be "in signs." Also think of a body whose base is a sign in this last sense which we have accepted but whose edge is on the axis of the zodiac. Such a body is called a "sign" in a fourth sense, according to which usage the whole world is divided into twelve equal parts, which are called "signs," and so whatever is in the world is in some sign.

COLURES. -- There are two other great circles in the sphere which are called "colures," whose function is to distinguish solstices and equinoxes. "Colure" is derived from *colon*, which is a member, and *uros*, which is a wild ox, because, just as the lifted tail of the wild ox, which is its member, describes a semicircle and not a complete circle, so a colure always appears to us imperfect because only one half of it is seen.

The colure distinguishing the solstices passes through the poles of the universe and through the poles of the zodiac and through the greatest declinations of the sun, that is, through the first degrees of Cancer and Capricorn. Wherefore, the first point of Cancer, where that colure intersects the zodiac, is called the "point of the summer solstice," because, when the sun is in it, the summer solstice occurs and the sun cannot approach further toward our zenith. The zenith is a point in the firmament directly above our heads. The arc of the colure which is intercepted between the point of the summer solstice and the equinoctial point is called the "sun's greatest declination" and is, according to Ptolemy, 23 degrees and 51 minutes, according to Almeon, 23 degrees and 33 minutes. Similarly, the first point of Capricorn is called the "point of the winter solstice," and the arc of the colure intercepted between that point and the equinoctial is called the "sun's greatest declination" and is equal to the former.

The other colure passes through the poles of the universe and through the points of Aries and Libra where are the two equinoxes, whence it is called the "colure distinguishing the equinoxes." Those two colures intersect at the poles of the world at spherical right angles. The signs of the solstices and equinoxes are stated in these verses:

These two solstices make, Cancer and Capricorn,
But Aries and Libra equal the nights to days.

THE MERIDIAN. -- There are yet two other great circles in the sphere, namely, the meridian and the horizon. The meridian is a circle passing through the poles of the world and through our zenith, and it is called "meridian" because, wherever a man may be and at whatever time of year, when the sun with the movement of the firmament reaches his meridian, it is noon for him. For like reason it is called the "circle of midday." And it is to be noted that cities of which one is farther east than the other have different meridians. The arc of the equinoctial intercepted between two meridians is called the "longitude" of the city. If two cities have the same meridian, then they are equally distant from east and from west.

THE HORIZON. -- The horizon is a circle dividing the lower hemisphere from the upper, whence it is called "horizon," that is, "limiter of vision."

It is also called the "circle of the hemisphere." Moreover, the horizon is twofold -- that is, right, and oblique or slanting. Those have a right horizon and right sphere whose zenith is on the equinoctial, since their horizon is a circle passing through the poles of the world cutting the equinoctial at right angles, wherefore it is called "right horizon" and "right sphere." But those to whom the pole of the world is raised above the horizon have an oblique or slanting horizon, since their horizon intersects the equinoctial at unequal and oblique angles and is called "oblique horizon" and the sphere "oblique" or "slanting." Moreover, the zenith over our heads is always the pole of the horizon.

ELEVATION OF THE POLE. -- From these things it is evident that the elevation of the pole of the world above the horizon is as great as the distance of the zenith from the equator, which is shown in this way. Since in every natural

day either colure twice joins or becomes identical with the meridian, whatever is true of one holds for the other. Take, then, a fourth part of the colure distinguishing the solstices, which is from the equinoctial to the pole. Take another fourth part of the same colure, which is from zenith to horizon. Since the zenith is the pole of the horizon, those two quarters, since they are quarters of one and the same circle, are equal. But if equals are subtracted from equals, or the same thing common to both is subtracted, the remainders will be equal. Therefore, if we subtract the common arc, namely, that between the zenith and the pole, the remainders will be equal, namely, the elevation of the pole above the horizon and the distance of the zenith from the equinoctial.

TROPICS OF CANCER AND CAPRICORN. -- Having told of the six great circles, we must speak of the four smaller circles. Be it noted, then, that the sun, when in the first point of Cancer or the summer solstice, as it is carried by the firmament describes a circle, which is the one last described by the sun in the direction of the Arctic pole. Wherefore it is called the "circle of the summer solstice" for the reason aforesaid, or the "summer tropic" from *tropos*, which is "turning," because then the sun begins to turn toward the lower hemisphere and to recede from us. The sun again, when in the first point of Capricorn or winter solstice, as it is carried by the firmament describes another circle which is the one last described by the sun in the direction of the Antarctic pole, whence 'tis called the "circle of the winter solstice" or the "winter tropic," because then the sun turns toward us.

ARCTIC AND ANTARCTIC CIRCLES. -- Since the zodiac slants from the equinoctial, the pole of the zodiac will decline from the pole of the world. Therefore, since the eighth sphere and the zodiac, which is a part of it, are moved about the axis of the world, the pole of the zodiac, too, will move about the pole of the world. And that circle which the pole of the zodiac describes about the Arctic pole of the world is called the "Arctic circle." And that circle which the other pole of the zodiac describes about the Antarctic pole is called the "Antarctic circle."

As great as is the maximum declination of the sun, so great is the distance of the pole of the world from the pole of the zodiac, which is shown in this way. Take the colure distinguishing the solstices which passes through the poles of the world and the poles of the zodiac. Since all quarters of one and the same circle are equal, the quarter of this colure between equator and pole is equal to the quarter of the same colure from the first point of Cancer to the pole of the zodiac. Then, if we subtract from those equals the common arc from the first point of Cancer to the pole of the world, the remainders will be equal, namely, the maximum declination of the sun and the distance from the pole of the world to the pole of the zodiac. Moreover, since the Arctic circle at every point is equidistant from the pole of the world, it is evident that that part of the colure which lies between the first point of Cancer and the Arctic circle is almost double the maximum declination of the sun or the arc of the same colure intercepted between the Arctic circle and the Arctic pole, which is equal to the maximum declination of the sun. Since that colure, like other circles in the sphere, has 360 degrees, a quarter of it will be 90 degrees. Then, since the maximum declination of the sun according to Ptolemy is 23 degrees and 51 minutes and of as many degrees is the arc which is between the Arctic circle and the Arctic pole, if those two combined, which make about 48 degrees, are subtracted from 90, the remainder will be 42 degrees, as is the arc of the colure which lies between the first point of Cancer and the Arctic circle. So it is clear that that arc is almost double the maximum declination of the sun.

It is also to be noted that the equinoctial with the four small circles are called "parallels," as it were equidistant, not that the first is as far from the second as the second is from the third, because this is false, as has already been shown, but because any two taken together are equidistant at every point. They are called the "equinoctial parallel," the "parallel of the summer solstice," the "parallel of the winter solstice," the "Arctic parallel", and the "Antarctic parallel." It is further to be noted that the four minor parallels, namely, the two tropics and the Arctic parallel and Antarctic parallel, distinguish five zones or five regions in the heaven. Therefore, Virgil:

Five zones possess the sky, of which one is ever
Red from blazing sun and ever burnt by fire. [3]

Also a like number of zones is distinguished on earth directly beneath the said zones. Wherefore, Ovid:

... and just as many zones are marked on earth. [4]

THE FIVE ZONES. -- That zone which lies between the tropics is said to be uninhabitable because of the heat of the sun, which ever courses between the tropics. Similarly, the zone of earth directly beneath it is said to be uninhabitable because of the fervor of the sun, which ever courses above it. But those two zones which are described by the Arctic circle and the Antarctic circle about the poles of the world are uninhabitable because of too great cold, since the sun is far removed from them. The same is to be understood of the zones of earth directly beneath them. But those two zones of which one is between the summer tropic and the Arctic circle and the other between the winter tropic and

the Antarctic circle are habitable and tempered from the heat of the torrid zone between the tropics and from the cold of the extreme zones which lie about the poles. The same is to be understood of the stretches of earth directly beneath them.

CHAPTER THREE

RISINGS AND SETTINGS OF THE SIGNS. -- The risings and settings of the signs are taken in two ways, according to the poets and according to the astronomers. The rising and setting of the signs according to the poets is threefold, namely, cosmic, chronic, and heliacal.

COSMIC RISING. -- Cosmic or mundane rising takes place when sign or star ascends above the horizon from the east by day. And albeit in each artificial day six signs rise, yet antonomastically that sign is said to rise cosmically with which and in which the sun rises in the morning. And this is rising in the strict and chief and daily sense. Of this rising we have an instance in the *Georgics*, where the planting of beans and millet in springtime, when the sun is in Taurus, is taught thus:

The white bull with gilded horns opens the year,
And the dog, yielding to adverse star, sets. [5]

COSMIC SETTING. -- Cosmic setting is a matter of opposition. When the sun rises with a sign, the opposite sign sets cosmically. This setting is spoken of in the *Georgics*, where is taught the sowing of wheat in late fall when the sun is in Scorpio. For when Scorpio rises with the sun, Taurus, where the Pleiades are, sets.

Ere Eoe Atlantides are hidden from you,
Consign the seed as you should to the furrow. [6]

CHRONIC RISING AND SETTING. -- Chronic or temporal rising takes place when sign or star, after sunset, emerges above the horizon from the east at night. It is called "temporal rising" because astronomical time begins with sunset. Of this rising we have an example in Ovid's *From Pontus*, where he complains of his prolonged exile, saying,

Pleias having risen makes four autumns, [7]

signifying by four autumns that four years had passed since he was sent into exile. But Virgil made the Pleiades set in the autumn, so they seem contradictory. But the explanation of this is that according to Virgil they set cosmically and according to Ovid they rise chronically, which may well happen on the same day but differently, since cosmic setting is with respect to daytime, but chronic rising is in the evening.

Chronic setting is a matter of opposition. Hence Lucan:

Then the short night shot Thessalian arrows. [8]

HELIALCAL RISING AND SETTING. -- Heliacal or solar rising occurs when sign or star can be seen by departure of the sun from it, which previously could not be seen because of the nearness of the sun. Ovid gives an example of this in the *Fasli*, saying:

Now aged Aquarius sits below with urn inclined. [9]

And Virgil in the *Georgics*:

And the Gnosian Star of the burning crown descends, [10]

which star, being next to Scorpio, was not visible while the sun was in Scorpio.

Heliacal setting takes place when the sun approaches a sign and by its presence prevents it from being seen. An example of this is the following verse:

And the dog, yielding to adverse star, sets. [11]

RIGHT ASCENSIONS. -- We next consider the rising and setting of the signs according to the astronomers and first in the right sphere. It should be remarked that the rising or setting of a sign is nothing else than the rising of that part

of the equinoctial circle which rises with that sign, when it comes above the horizon, or the setting of that part of the equinoctial which sets with that sign when it sets, that is, moves westward below the horizon. A sign is said to rise "vertically" when a larger part of the equator rises with it, "obliquely" where a smaller part rises with it. The same is to be understood of setting.

It should be known that in the right sphere the four quarters of the zodiac beginning from four points, namely, from the two solstices and two equinoxes, are equal in their ascensions, that is, as much time as a quarter of the zodiac consumes in rising, so much time the quarter of the equinoctial corresponding to it takes to rise; but the parts of those quarters vary and do not have equal ascensions, as will now appear.

There is the rule that every two arcs of the zodiac opposite and equal, equally distant from one of the four points already mentioned, have equal ascensions. Whence it follows that opposite signs have equal ascensions. And this is what Lucan says in speaking of the march of Cato into Libya toward the equator:

They do not move obliquely, nor is Scorpio straighter
Than Taurus, or Aries give its time to Libra,
Or Astrea bid Pisces to descend slowly.
Chiron is par with Gemini, the same as burning Carcinus
Is humid Aegoceros, nor is Leo moved more than the Urn. [12]

Here Lucan says that to dwellers beneath the equinoctial opposite signs have equal ascensions and settings. Moreover, the opposing signs are indicated by this verse:

Sunt li. an. scor. tau. sa. gemi. cap. can. a. le. pis. vir.

Note that this argument does not hold: these two arcs are equal and begin to rise together and always a greater part of one rises than of the other; therefore, that arc rises more rapidly of which a larger part always rises. An example of this argument is shown in the case of parts of the aforesaid quarters. For if the fourth part of the zodiac is taken, which extends from the beginning of Aries to the end of Gemini, a larger part of the quarter of the zodiac always rises [13] than of the quarter of the equinoctial corresponding to it. Yet those quarters complete their rising simultaneously. The same is the case with the quarter of the zodiac from the beginning of Libra to the end of Sagittarius. Also if the quarter of the zodiac is taken which extends from the beginning of Cancer to the end of Virgo, a larger part will always rise of the quarter of the equinoctial than of the quarter of the zodiac corresponding to it. Yet those two quarters complete their rising simultaneously. The same is true of the quarter of the zodiac from the first point of Capricorn to the end of Pisces.

OBLIQUE ASCENSIONS. -- In the oblique or slanting sphere, halves of the zodiac equal their ascensions. I mean the halves which are taken from the two equinoctial points, because the half of the zodiac which extends from the beginning of Aries to the end of Virgo rises with the half of the equinoctial corresponding to it. Similarly, the other half of the zodiac rises with the other half of the equinoctial. But the parts of those halves vary in their risings, since in the half of the zodiac from the beginning of Aries to the end of Virgo a larger part of the zodiac always rises than of the equinoctial. Yet those halves complete their rising simultaneously. The opposite happens in the other half of the zodiac, which extends from the beginning of Libra to the end of Pisces, for always a larger part of the equinoctial rises than of the zodiac. Yet those halves complete their rising simultaneously. So this case is clearly against the argument aforesaid.

Moreover, the arcs which succeed Aries to the end of Virgo in the oblique sphere lessen their ascensions compared to the ascensions in the right sphere; and the arcs which succeed Libra to the end of Pisces in the oblique sphere increase their ascensions over the ascensions of the same arcs in the right sphere. That is, they increase by the same quantity as the arcs succeeding Aries lessen.

From this it is evident that two equal and opposite arcs in the slanting sphere have their combined ascensions equal to the ascensions of the same arcs taken together in the right sphere, because as much as is the diminution on the one hand, so much is the addition on the other.

The rule, indeed, is that any two arcs which are equal and equally distant from either of the equinoctial points have unequal(?) ascensions.

INEQUALITIES OF DAYS. -- From the aforesaid it is also clear that natural days are unequal; for a natural day is

the revolution of the equinoctial with as much as the sun covers meanwhile by its own movement against the firmament. But, since the ascensions of those arcs are unequal, as is evident from the foregoing, alike in right sphere as in oblique, and natural days are reckoned according to the increase of those ascensions, they will of necessity be unequal, in the right sphere for a single reason -- the obliquity of the zodiac -- in the oblique sphere for two reasons -- the obliquity of the zodiac and the obliquity of the oblique horizon. Moreover, a third cause is wont to be assigned -- the eccentricity of the sun's orbit.

MOVEMENT OF THE SUN. -- It also should be noted that the sun, moving from the first point of Capricorn through Aries to the first point of Cancer with the sweep of the firmament, describes 182 parallels, to which parallels, although they are not really circles but spirals, since there is no sensible error in this, no violence is done if they are called "circles," of which number of circles are the two tropics and the equinoctial. Also the sun describes these circles with the sweep of the firmament as it descends from the first point of Cancer through Libra to the first point of Capricorn; and those circles are called the "circles of natural days." But the arcs above the horizon are the arcs of artificial days, and the arcs below the horizon are the arcs of the nights.

In the right sphere the horizon, since it passes through the poles of the world, divides all those circles into equal parts, whence the arcs of days are the same as those of nights for persons living at the equator. Hence it is evident that for persons living at the equator it is always equinox, wherever the sun may be in the firmament.

But in the slanting sphere the oblique horizon divides the equinoctial alone into two equal parts. Hence, when the sun is at either equinoctial point, the arc of day equals the arc of night, and there is equinox the world over. But the oblique horizon divides all the other circles into unequal parts, so that in all the circles from the equinoctial to the Tropic of Cancer and at the Tropic of Cancer itself the arc of day is greater than that of night, that is, the arc above the horizon than that below the horizon. Hence all the time that the sun is moved from the beginning of Aries through Cancer to the end of Virgo, the days are longer than the nights and so much the more as the sun comes closer to Cancer. In all the other circles which are between the equinoctial and the Tropic of Capricorn the arc is greater below the horizon than above. Hence the arc of day is less than the arc of night; and, according to the proportion between the arcs, the days grow less than the nights, and the closer the circles get to the winter tropic, the more the days shorten.

DAY AND NIGHT. -- Wherefore it appears that, if two circles are taken equidistant in their various parts from the equinoctial, as great as is the arc of day in the one, so great is the arc of night in the other. From this it seems to follow that if two natural days in the year are taken equally remote from either equinoctial point in opposite directions, as long as is the artificial day in one case, so long is the night in the other, and conversely. But this is with reference to ordinary observation in fixing the horizon. For reason determines more exactly by discounting the movement of the sun contrary to the firmament in the obliquity of the zodiac.

The more the pole is elevated above the horizon, so much more are the days of summer lengthened when the sun is in the northern signs. Conversely, when the sun is in the southern signs the days are so much shorter than the nights.

RIGHT AND OBLIQUE ASCENSIONS. -- It is to be noted that the six signs from the beginning of Cancer through Libra to the end of Sagittarius have their combined ascensions greater than the ascensions of the other six signs from the beginning of Capricorn through Aries to the end of Gemini. Hence those six signs first mentioned are said to rise erect, but the others obliquely. Wherefore the verses:

They rise aright, oblique descend from Cancer's star
Till Chiron ends, but the other signs
Are prone at birth, descend by a straight path.

And when we have the longest day of summer, when the sun is in the beginning of Cancer, then six signs rise vertically by day but six obliquely at night. Conversely, when we have the shortest day of the year, when the sun is in the beginning of Capricorn, then those six signs which rise by day do so obliquely, but by night the other six rise vertically. When, moreover, the sun is at either equinoctial point, then by day three signs rise vertically and three obliquely, and at night the same.

For the rule is: However short or long the day or night may be, six signs rise by day and six by night, nor because of the length or brevity of day or night do more or fewer signs rise.

From these facts it is gathered that, since a natural hour is the space of time in which half a sign rises, there are

twelve natural hours in each artificial day, and so also in the night. Moreover, in all the circles which parallel the equator to north or south, days or nights are lengthened or shortened according as more or fewer signs rise vertically or obliquely by day or night.

DWELLERS AT THE EQUATOR. -- Moreover, it is to be noted that in the case of those whose zenith is in the equinoctial the sun twice a year passes directly overhead, namely, when in the beginning of Aries and in the beginning of Libra; and then there are two high solstices for them when the sun passes directly overhead. Again there are two low solstices for them when the sun is in the first points of Cancer and Capricorn, and they are called "low" because then the sun is farthest removed from their zenith. From what has been said it is clear that, while they always have equinox, they will have in the course of a year four solstices, two high and two low. It also is evident that they have two summers when the sun is in either of the equinoctial points or nearly so, and likewise two winters when the sun is in the first points of Cancer and Capricorn or thereabouts. And this is why Alfraganus says that for them summer and winter are of one and the same complexion, since those two seasons which are winter and summer for us are for them two winters, and the difference is made clear by these lines of Lucan:

'Tis understood this is the place where the circle
Of the high solstice hits that of the signs midway. [14]

Here Lucan calls the equinoctial "the circle of the high solstice," on which two high solstices happen to those living at the equator. He calls the zodiac "circle of the signs," which the equinoctial "hits," that is, divides "midway," that is, halved or divided in two.

These also during the year have four shadows; for, when the sun is in either equinoctial point, their shadow in the morning falls toward the west, in the evening in the opposite direction. At noon their shadow is perpendicular, when the sun is overhead. When the sun is in the northern signs, their shadow lies toward the south; but when the sun is in the southern signs, then their shadow falls toward the north.

For them, too, the stars which are near the poles rise and set, and for others living near the equator. Hence Lucan:

Then Roman fury moves the remote Orestae
And Carmanian leaders whose ether, now turned
Southward, yet does not see Arcton quite submerged,
And there swift Boötes shines in scant night. [15]

Therefore it is setting and shines little. Ovid, too, says of the same star:

The guardian of the Erimanthean bear is dipped in ocean
And with his star disturbs the waters of the sea. [16]

That is to say, it sets vertically. But in our locality those stars never set. Wherefore Virgil:

This vertex is ever above us. [17]

And Lucan:

Axis never-setting, bright with both Bears. [18]

Also Virgil:

Arctos dreading to touch the ocean wave. [19]

BETWEEN THE EQUATOR AND TROPIC OF CANCER. -- To those whose zenith is between the equinoctial and the Tropic of Cancer it happens twice a year that the sun passes directly overhead, which is shown thus. Suppose a circle parallel to the equinoctial passes through their zenith. That circle will intersect the zodiac at two points equidistant from the beginning of Cancer. Therefore, when the sun is at those two points it passes through their zenith; wherefore they have two summers and two winters, four solstices and four shadows, like those living at the equator. And some say Arabia is so situated. Hence Lucan, speaking of the Arabs coming to Rome to aid Pompey, says:

You Arabs have come to a world unknown to you

And marvel that the shade of trees is never leftward, [20]

since in their country shadows were sometimes to their right, sometimes to their left, sometimes perpendicular, sometimes to the east, sometimes to the west. But when they came to Rome beyond the Tropic of Cancer, then the shadows were always northward.

AT THE TROPIC OF CANCER. -- To those whose zenith is at the Tropic of Cancer it happens that the sun once a year passes through their zenith, namely, when it is in the first point of Cancer, and then for one hour of one day of the whole year their shadow is perpendicular. The city of Syene Is said to be so situated. Hence Lucan:

Syene's never varying shadow. [21]

Understand this as applying to noon of a single day; for all the rest of the year their shadow is northward.

BETWEEN THE TROPIC AND THE ARCTIC CIRCLE. -- But to those whose zenith is between the Tropic of Cancer and the Arctic circle it happens that the sun is never directly overhead and their shadow always lies toward the north. Such is our situation. Also it is to be noted that, according to some persons, Ethiopia or a part of it is this side of the Tropic of Cancer. Hence Lucan:

And Ethiopia which alone is untouched
By any region of the sign-bearing pole,
Except the hoof tip of curvetting Taurus. [22]

For they say that sign is here taken equivocally, both for a twelfth part of the zodiac and for the outline of the animal which, for the most part, is within the sign to which it gives its name. Wherefore Taurus, although it is, for the most part, within the zodiac, extends its foot beyond the Tropic of Cancer and so touches Ethiopia, although no part of the zodiac touches it. For if the foot of Taurus were extended toward the equinoctial so that it was in the direction of Aries or another sign, then it would be touched by Aries and Virgo or other signs, which is evident by drawing a circle parallel to the equinoctial through the zenith of the Ethiopians and Aries and Virgo or other signs. But, since philosophical reason is opposed to this, for they would not be so black if they were born in the temperate habitable zone, it must be said that that part of Ethiopia of which Lucan is speaking is beneath the equinoctial circle and that the foot of Taurus, of which he speaks, extends toward the equinoctial. But there is a distinction between cardinal signs and regions; for "cardinal signs" are the name for the two signs in which the solstices occur and the two in which the equinoxes occur, while the intermediate signs are called "regions." And in this way it becomes clear that, although Ethiopia is at the equator, it is not touched by any region but merely by two cardinal signs, namely, Aries and Libra.

AT THE ARCTIC CIRCLE. -- To those whose zenith is at the Arctic circle it happens on every day of the year that their zenith is identical with the pole of the zodiac, and then they have the zodiac or ecliptic as their horizon. And this is what Alfraganus says, that there the circle of the zodiac is bent over the circle of the hemisphere. But, since the firmament is in continual motion, the circle of the horizon will intersect the zodiac instantaneously, and, since they are great circles in the sphere, they will intersect in equal parts. Hence one half of the zodiac rises immediately above the horizon, and the other sinks below the horizon. And this is what Alfraganus says, that six signs set suddenly there, and the other six rise with the whole equinoctial. And, since the ecliptic is their horizon, when the sun is in the first point of Cancer they will have a day of 24 hours and a quasi-instant for night, since the sun touches the horizon for an instant and straightway rises, and that amount of contact is their night. The opposite happens when the sun is in the first point of Capricorn, for then they have a night of 24 hours and a quasi-instant for a day.

BETWEEN THE ARCTIC CIRCLE AND THE NORTH POLE. -- To those whose zenith is between the Arctic circle and the North Pole, it happens that their horizon will intersect the zodiac in two points equidistant from the beginning of Cancer. And, as the firmament revolves, this intercepted portion of the zodiac always remains above the horizon. Hence it is clear that, so long as the sun is in that portion, there will be continuous day without night. Therefore, if it is as much as one sign, there will be continuous day there for one month without night. If the sun remains for the extent of two signs, there will be continuous day without night for two months, and so on. It likewise happens that the portion intercepted between two points equidistant from the beginning of Capricorn is always left below the horizon. Hence, when the sun is in that intercepted portion, there will be one continuous night without day, short or long according to the extent of the portion intercepted. Moreover, the remaining signs which rise and set for them, rise and set preposterously. They rise preposterously, as Taurus before Aries, Aries before Pisces, Pisces before Aquarius. Yet the signs opposite these rise in right order. They set preposterously, as Scorpio before Libra, Libra before Virgo,

<Virgo before Leo>. Yet the signs opposite these set vertically.

AT THE NORTH POLE. -- To those whose zenith is at the Arctic pole it happens that the horizon is identical with the equinoctial. Hence, since the equinoctial intersects the zodiac in equal parts, their horizon leaves half of the zodiac above and half below it. Wherefore, while the sun is moving through that half which extends from the beginning of Aries to the end of Virgo, there will be one continuous day without night; and when the sun is moving in the other half, which extends from the beginning of Libra to the end of Pisces, there will be one continuous night without day. Wherefore, one half of the whole year will be one artificial day, and the other half one night. Hence there the whole year is one natural day. But since there the sun is never more than 23 degrees below the horizon, it seems that they have continuous day without night; for we speak of its being day before the rise of the sun above the horizon. But this is according to popular usage; for in a scientific sense it is not artificial day except from the rising of the sun above the horizon to its setting beneath the horizon. As for that argument again, that there ought to be perpetual light there, it should be said that the air there is misty and dense, for the rays of the sun there are feeble and raise more vapors than they can consume, so that the air is not clear.

THE SEVEN CLIMES. -- Let a circle be imagined on the earth's surface directly under the equinoctial. And suppose another circle on the earth's surface passing from east to west through the poles. These two circles will intersect in two places at right spherical angles and divide the whole earth into four parts, one of which is our habitable region, namely, that which is intercepted between the semicircle drawn from east to west along the equator and the semicircle carried from east to west through the Arctic pole. Nor is that quarter entirely habitable, since parts of it near the equator are uninhabitable because of too great heat, and parts near the pole because of too great cold. Suppose, then, a line parallel to the equator dividing the parts uninhabitable on account of heat from those habitable parts toward the north. And suppose another line equidistant at all points from the Arctic pole dividing the parts which are uninhabitable for cold from the habitable parts toward the equator. Between these two extreme lines suppose six lines parallel to the equator, which, with the two former, divide the whole habitable quarter into seven parts which are called the "seven climes."

FIRST CLIME. -- The middle of the first clime is where the length of the longest day is 13 hours and the pole is elevated above the horizon 16 degrees, and it is called the "clime of Meroe." It begins where the length of the longest day is 12 $\frac{3}{4}$ hours and the pole is elevated above the horizon 12 $\frac{3}{4}$ degrees. And its breadth extends to the place where the length of the longest day is 13 $\frac{1}{4}$ hours and the pole is elevated above the horizon 20 $\frac{1}{2}$ degrees, which distance is 440 miles.

SECOND CLIME. -- The middle of the second clime is where the longest day is 13 $\frac{1}{2}$ hours and the elevation of the pole above the horizon is 24 $\frac{1}{4}$ degrees, and it is called the "clime of Syene." Its breadth from the end of the first clime to a place where the longest day is 13 $\frac{3}{4}$ hours and the pole is elevated 27 $\frac{1}{2}$ degrees, is a distance of 400 miles.

THIRD CLIME. -- The middle of the third clime is where the length of the longest day is 14 hours, and the elevation of the pole above the horizon is 30 $\frac{3}{4}$ degrees, and it is called the "clime of Alexandria." Its breadth is from the end of the second clime to where the longest day is 14 $\frac{1}{4}$ hours, and the altitude of the pole 33 $\frac{2}{3}$ degrees, which is a distance of 350 miles.

FOURTH CLIME. -- The middle of the fourth clime is where the longest day is 14 $\frac{1}{2}$ hours and the altitude of the axis is 36 $\frac{2}{5}$ degrees, and it is called the "clime of Rhodes." Its breadth is from the end of the third clime to where the longest day is 14 $\frac{3}{4}$ hours and the elevation of the pole is 39 degrees, which distance is 300 miles.

FIFTH CLIME. -- The middle of the fifth clime is where the major day is 15 hours and the elevation of the pole is 41 $\frac{1}{3}$ degrees, and it is called the "clime of Rome." Its breadth is from the end of the fourth clime to where the longest day is 15 $\frac{1}{4}$ hours and the elevation of the axis is 43 $\frac{1}{2}$ degrees, which distance is 255 miles.

SIXTH CLIME. -- The middle of the sixth clime is where the longest day is 15 $\frac{1}{2}$ hours and the pole is elevated above the horizon 45 $\frac{2}{5}$ degrees, and it is called the "clime of Boristhenes." Its breadth is from the end of the fifth clime to where the length of the longest day is 15 $\frac{3}{4}$ hours and the elevation of the axis is 47 $\frac{1}{4}$ degrees, which distance is 212 miles.

SEVENTH CLIME. -- The middle of the seventh clime is where the longest day is 16 hours and the elevation of the pole above the horizon is 48 $\frac{2}{3}$ degrees, and it is called the "clime of Ripheon." Its breadth is from the end of the sixth clime to where the maximum day is 16 $\frac{1}{4}$ hours and the pole is elevated above the horizon 50 $\frac{1}{2}$ degrees,

which space of earth is 185 miles.

BEYOND IT. -- Beyond the end of this seventh clime there may be a number of islands and human habitations, yet whatever there is, since living conditions are bad, is not reckoned as a clime. Therefore, the whole difference between the initial limit of the climes and their end is 3 1/2 hours, and of elevation of the pole above the horizon 38 degrees. So then we have made clear the breadth of each clime from its beginning toward the equator to its end toward the Arctic pole, and that the breadth of the first clime is greater than the latitude of the second, and so on. The length of a clime may be said to be the line drawn from east to west parallel to the equator; wherefore the length of the first clime is greater than the length of the second and so on, which happens because the sphere narrows down.

CHAPTER FOUR

MOVEMENT OF THE SUN. -- It should be noted that the sun has a single circle in which it is moved in the plane of the ecliptic, and it is eccentric. Any circle is called "eccentric" which, like that of the sun, dividing the earth into equal parts, does not have the same center as the earth but one outside it. Moreover, the point in the eccentric which approaches closest to the firmament is called *aux* or *augis*, meaning "elevation." The opposite point, which is farthest removed from the firmament, is called the "opposition" of the *aux*.

Moreover, there are two movements of the sun from west to east, one of which is its own in its eccentric, by which it is moved every day and night about 60 minutes. The other is the slower movement of the sphere itself on the poles of the axis of the circle of the signs, and it is equal to the movement of the sphere of the fixed stars, namely, 1 degree in a hundred years. From these two movements, then, is reckoned the sun's course in the circle of the signs from west to east, by which it cleaves the circle of the signs in 365 days and a fourth of one day, except for a small fraction which is imperceptible.

OF THE OTHER PLANETS: EQUANT, DEFERENT, AND EPICYCLE. -- Every planet except the sun has three circles, namely, equant, deferent, and epicycle. The equant of the moon is a circle concentric with the earth and in the plane of the ecliptic. Its deferent is an eccentric circle not in the plane of the ecliptic -- nay, one half of it slants toward the north and the other toward the south -- and the deferent intersects the equant in two places, and the figure of that intersection is called the "dragon" because it is wide in the middle and narrow toward the ends. That intersection, then, through which the moon is moved from south to north is called the "head of the dragon," while the other intersection through which it is moved from north to south is called the "tail of the dragon." Deferent and equant of each planet are equal, and know that both deferent and equant of Saturn, Jupiter, Mars, Venus, and Mercury are eccentric and outside the plane of the ecliptic, and yet those two are in the same plane. Also every planet except the sun has an epicycle. An epicycle is a small circle on whose circumference is carried the body of the planet, and the center of the epicycle is always carried along the circumference of the deferent.

STATIONARY, DIRECT, AND RETROGRADE. -- If, then, two lines are drawn from the center of the earth to include an epicycle, one on the east and the other on the west, the point of contact on the east is called the "first station," while the point of contact to the west is called the "second station." And when a planet is in either of those stations it is called "stationary." The upper arc of the epicycle intercepted between those two stations is called "direction," and when the planet is there it is called "direct." But the lower arc of the epicycle between the two stations is called "retrogradation," and a planet existing there is called "retrograde." But the moon is not stationary, direct, or retrograde because of the swiftness of its motion in its epicycle.

CAUSE OF LUNAR ECLIPSE. -- Since the sun is larger than the earth, it is necessary that half the sphere of earth be always illuminated by the sun and that the shadow of the earth, extended into the air like a cone, diminish in circumference until it ends in the plane of the circle of the signs inseparable from the nadir of the sun. The nadir is a point in the firmament directly opposite to the sun. Hence, when the moon, at full is in the head or tail of the dragon beneath the nadir of the sun, then the earth is interposed between sun and moon, and the cone of the earth's shadow falls on the body of the moon. Wherefore, since the moon has no light except from the sun, it actually is deprived of light and there is a general eclipse, if it is in the head or tail of the dragon directly but partial if it is almost within the bounds determined for eclipse. And it always happens at full moon or thereabouts. But, since in every opposition -- that is, at full moon -- the moon is not in the head or tail of the dragon or beneath the nadir of the sun, it is not necessary that the moon suffer eclipse at every full moon.

CAUSE OF SOLAR ECLIPSE. -- When the moon is in the head or tail of the dragon or nearly within the limits and in conjunction with the sun, then the body of the moon is interposed between our sight and the body of the sun.

Hence it will obscure the brightness of the sun for us, and so the sun will suffer eclipse -- not that it ceases to shine but that it fails us because of the interposition of the moon between our sight and the sun. From these it is clear that a solar eclipse should always occur at the time of conjunction or new moon. And it is to be noted that when there is an eclipse of the moon, it is visible everywhere on earth. But when there is an eclipse of the sun, that is by no means so. Nay, it may be visible in one clime and not in another, which happens because of the different point of view in different climes. Whence Virgil most aptly and concisely expresses the nature of either eclipse:

Varied defects of the moon, and of the sun travails. [23]

ECLIPSE DURING THE PASSION MIRACULOUS. -- From the aforesaid it is also evident that, when the sun was eclipsed during the Passion and the same Passion occurred at full moon, that eclipse was not natural -- nay, it was miraculous and contrary to nature, since a solar eclipse ought to occur at new moon or thereabouts. On which account Dionysius the Areopagite is reported to have said during the same Passion, "Either the God of nature suffers, or the mechanism of the universe is dissolved."

NOTES:

1. The *mediclinium*, or "indicator," is described in the first part, fourth chapter, of Messahala's treatise on the astrolabe (English translation in R. G. Gunther, *Early Science at Oxford*, V [1929], "Of Making an Allidada Which Is Called a Rule or Mediclinium").
2. *Georgics* i. 242-43.
3. *Georgics* i. 233-34.
4. *Metamorphoses* i. 48.
5. *Georgics* i. 217-18.
6. *Georgics* i. 221, 223.
7. *Ex Ponto* viii, 28.
8. *Pharsalia* iv. 528.
9. *Fasli* ii. 457.
10. *Georgics* i. 222.
11. *Georgics* i. 218.
12. Lucan *Pharsalia* ix. 533-37.
13. That is, has risen; otherwise Sacrobosco is in error.
14. *Pharsalia* ix. 531-32.
15. *Pharsalia* iii. 249-52.
16. *Tristia* i. 4. 1-2, or in some editions, i. 3. 103-4.
17. *Georgics* i. 242-43.
18. *Pharsalia* viii. 175. By "twin Arcton" is meant Ursa Major and Ursa Minor.
19. *Georgics* i. 246.
20. *Pharsalia* iii. 247-48.
21. *Pharsalia* ii. 587.
22. *Pharsalia* iii. 253-55.
23. *Georgics* ii. 478.