1512-2012: From Cosmography to the Cosmonauts, Gerard Mercator and Gemma Frisius

The Schiller Institute

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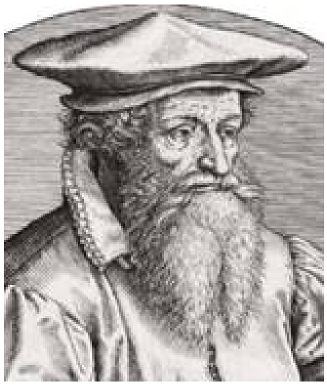
The Erasmus Generation

The Flemish cartographer Gérard Mercator (1512-1594), a typical product of the "Erasmus generation".



In 2012, we celebrate in Belgium where he was born and in Germany where he died in Duisburg, the 500th anniversary of the birth of the founder of what is called the Belgian school of geography—Gerard Mercator, who died in 1594 at the age of 82.

History retains that he succeeded in projecting the surface of a sphere on a flat surface, a discovery akin to solving the problem of squaring the circle.

The first reason that attracts our interest to Mercator and his friend and teacher Gemma Frisius (1508-1555) is that these two exceptional individuals represent by far and large the most creative minds of what I call the "Erasmus generation," in reality a youth movement composed of the pupils and followers of the latter.

The existence the "Erasmus generation" is in general denied because most official historians try to sell us the lie that Erasmus was merely some kind of funny literary maverick intruding into the theological debates of his days, while of course Mercator and Frisius are recognized as great scientists. A lunar crater was even named after Frisius and another was named Stadius after one of Frisius' many pupils, the Flemish astronomer Johannes Stadius.

Recently, however, in a well-documented article by Professor Jan Papy of the University of Leuven [1] , it was established in great detail that the revival of science in the first half of the 16th Century was a direct spinoff effect of a broad linguistic revolution—beyond learning Flemish and French, hundreds of youth, by studying Greek, Latin, and Hebrew, could fully access the treasures of classical Greek philosophy as well as the best authors that wrote in Latin and Hebrew. At last they could read Plato in the original, and also the scientific explorations of Thales, Anaxagoras, Pythagoras, Eratosthenes, Archimedes, Galen, Vitruvius, Pliny the Elder, Euclid, and Ptolemy, and overthrow their hypotheses with more adequate ones.

Initially undertaken by Italian humanists in dialogue with exiled Greek scholars, the rigorous analysis and philological examination of the Gospel and the early Church Fathers allowed the humanists to bring down the tyranny of Aristotle, which was strangulating Christianity, and to revive the ideals, beauty, spirit, and impetus of the Primitive Church [2] .

The Sisters and Brothers of the Common Life

North of the Alps, it were the Sisters and Brothers of the Common Life, a laymen teaching order inspired by Geert Groote (1340-1384) that would open the first schools teaching the three sacred languages. Today, one might think they were some strange Trotskyite sect because each pupil changed his original name into a latinized version of it. Hence, Gerard (named so in honor of Geert Groote) Kremer (cramer or merchand) was turned into *Mercator*.

Erasmus, himself a pupil of the Brothers in Deventer [3] , used them as his model to create in 1517 in Louvain, the famous Three Language College (*Drietongen*), which became a hotbed for training creative thinkers [4] . For the latter, mastering the language and reading a major text was only the start. Beyond, the issue was to penetrate the history and intent of the author, to know the cultural context, the state of science and law, the history and the laws of the author’s country, its geography and cosmography—in short, the origin and history of the universe. This “modern” approach (i.e., disputation and critical examination of source material) of the Three Language College, after having demonstrated its efficiency in clarifying the Gospel, would now spread over Europe and be fruitfully applied to all other domains of human knowledge.

Enter Gemma Frisius

Medical doctor and mathematician Gemma Frisius (1508-1555).

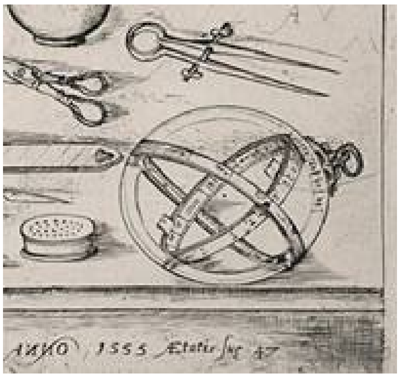
Any serious work on Mercator has to start with Gemma Frisius. Despite a physical handicap, Frisius, an orphan, is sent to the best school in Groningen (today in the North of the Netherlands). Then he enters Louvain University at The Lily, a department where Italian humanism was already being studied. Receiving his *Magister Artes* in 1528, Frisius enters the Three Language College where he develops close relations with major humanists of the day, all in close working relations with Erasmus himself [5] .

An astrolabium constructed by Frisius and Mercator (detail of the preceding figure).

Frisius starts by publishing a reworked version of *Cosmography*, a very popular book of the German astronomer Petrus Apianus (1495-1552). Frisius' new edition of this work immediately attracts the attention of Bishop Johan Dantiscus (1486-1548), the Polish ambassador to the court of Charles V. Dantiscus, himself a correspondent and fervent follower of Erasmus, will be the main protector of Frisius as well as Copernicus.

Unsatisfied with the lack of precision of scientific instrumentation available at that time, Frisius, while still a student, opens his own workshop in Louvain to produce celestial and earth globes, astrolabes, "Jacob staffs," astronomical rings, and other instruments.

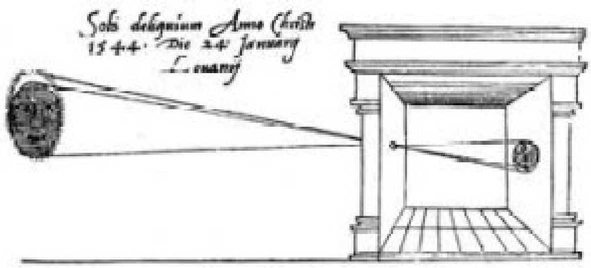
Astronomical ring elaborated by Gemma Frisius (detail of preceding image).



These instruments, nearly all simplified spinoffs of the astrolabe, a scientific measurement instrument believed to be invented by the Greek astronomer Hipparchus (2nd Century BC), allow an observer to find his position on the Earth by measuring the angle between a star or planet in the sky and the horizon. But we will come to that soon.

Frisius, in a drive for mass education, simultaneously publishes small booklets explaining how to use each instrument. The quality and exceptional precision of the instruments produced by the workshop of Frisius will be praised by Tycho Brahe and Johannes Kepler, the latter using some of Frisius' observations and making his own some of Frisius' methods. Frisius also describes the use of a camera obscura, a dark room, to observe solar eclipses, a method later also employed by Kepler and other astrophysicists [6] .

Gemma Frisius' description of a dark room to observe solar eclipses, a method later employed by Johannes Kepler.

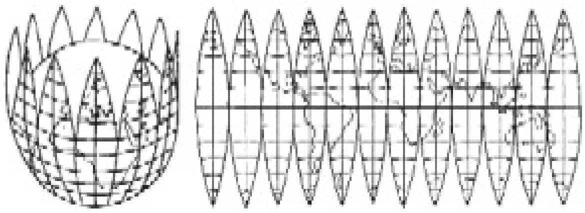


While teaching medicine at Louvain University, Frisius gives private master classes to youth interested in cosmography. One can hardly doubt about the quality of his teachings because at least four of those attending his courses became "big names" of science in Belgium by accomplishing revolutions in their own scientific domains—Gerard Mercator in cartography, Andreas Vesalius in anatomy, Rembert Dodoens in Botany, and Johannes Stadius in astronomy.

Mercator Engraver

Born in Rupelmonde between Antwerp and Brussels, Mercator, after being trained by the Brothers of the Common Life in 's-Hertogenbosch [7] , also enters Louvain University.

Rather than producing each globe manually as Martin Behaim did before, Frisius and Mercator used printing techniques developed by Albrecht Dürer in his handbook "On measurement".



Thrown into doubt by the dictatorship of Aristotelian dogma that was taking over Louvain University [8] , Mercator joins Frisius' workshop and is trained in the science of instrument building. Trained as an engraver, Mercator works with Frisius in Louvain and Antwerp to produce earth globes, a lucrative activity that guaranteed them a substantial income and independence.

Together, they will produce impressively precise and remarkably elegant globes. Rather than producing each globe manually as was done by Martin Behaim before, they used printing techniques. On each sheet of paper, four slides of an "unfolded" globe were printed in such a way that they could be assembled, a method already described in Albrecht Dürer's manual on geometry [9] . It should be noted that Dürer, as a participant of the discussion group called the "Pirckheimer circle" in Nuremberg, was up to date on cartography and lived in Antwerp till 1521.

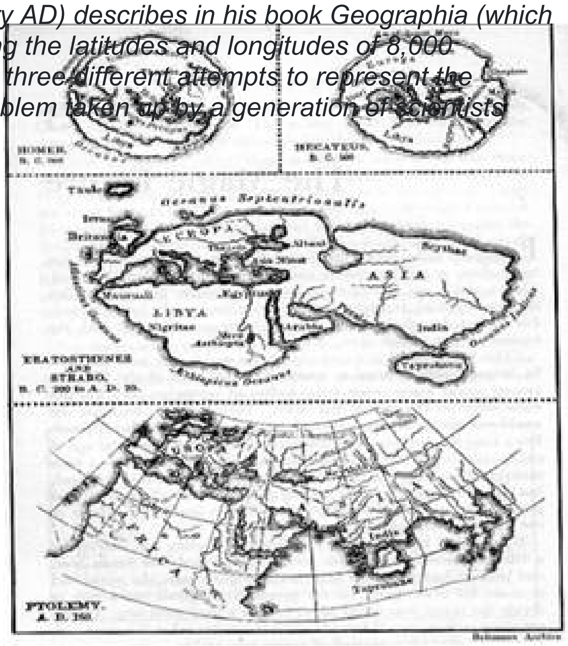
A Real Science Beyond Sense-Deception

The second reason for interest in the achievements of Frisius and Mercator is their scientific method. By reworking classical Greek science, they will free science from the slavery of empiricism. Distances after all, are hard to estimate with the senses. It is quite difficult to touch, to taste, to smell, to hear, and even to see a distance with precision!

Let us go to the core of the matter. Imagine you live in a world without airplanes, without photography, without satellites, without GPS, and without Google maps and you have to locate yourself on the surface of a rotating globe. Remember that a good map allows you to gain a lot of time.

For centuries map makers had to face the following challenges.

First, the issue of scale: The bigger the map, the bigger the number and amount of detail of locations that can be presented. Inversely, the amount of detail decreases as the map becomes smaller. For measurement instruments, the same can be said [10] .



The Roman astronomer Claudius Ptolemy (2nd Century AD) describes in his book Geographia (which survived without maps) a system of coordinates defining the latitudes and longitudes of 8,000 locations. Dissatisfied with the result, he also indicated three different attempts to represent the spherical character of the globe on a flat surface, a problem taken up by a generation of scientists including Nicolas of Cusa.

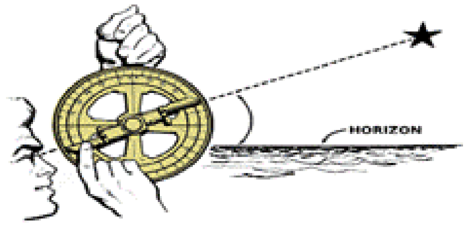
Next stands the challenge of geo-location. The writings of the Roman astronomer Claudius Ptolemy (2nd Century AD), well known for his major errors concerning the organization of the Solar system, nevertheless transmits some insights acquired by Greek astronomers (e.g., Eudoxius, Eratosthenes, and Hipparchus). Ptolemy's *Geographia* (which survived without maps) offers a system of coordinates defining the latitudes and longitudes of 8,000 locations. Dissatisfied by the result, he also indicated three different attempts to represent the spherical character of the globe on a flat surface, a problem taken up by a generation of scientists including Nicolas of Cusa.

To discover where he stands on the surface of the globe of the Earth, man is forced to go beyond sense-perception. The early maps for mariners were nothing but observations made from a ship following the coast line. This empirical approach can succeed to some extent when in smaller areas, such as the Mediterranean basin. However, to cross the oceans to other continents, these maps utterly fail and represented a mortal danger to those that relied upon them. To go to the Americas, it was said ironically, "Go south. Once the butter melts in your cupboard, turn right and go straight all along …"

To go beyond this limit, and define one's position on the surface of the earth globe one has to be able to reach further and use the positions of distant elements (e.g., planets and stars) or even invisible physical principles such as the Earth's magnetism and other phenomena. In the footsteps of Columbus, Mercator studied the Earth's magnetic field in-depth [11] .

Latitudes and Longitudes

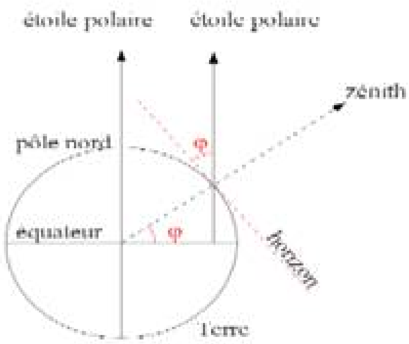
A mariner's astrolabe allows measuring the angle between the horizon and a celestial body (e.g., star or planet).

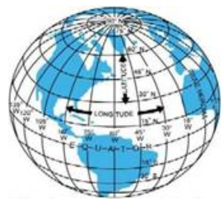


In the northern hemisphere, the easiest method is to measure the angle between the pole star (Polaris) and the horizon, especially because this angle directly equals the latitude of the observer, i.e., the angle between the equator, the center of the Earth, and the geographical position of the observer.

In the northern hemisphere the Pole star appears to us as (nearly) exactly above the rotating axis of the Earth and seems fixed at the center of the firmament. Eight times bigger and 1,600 times more luminous than the Sun, the Pole star is easy to find thanks to the constellation of the Big Dipper (Ursa Major).

The angle between the horizon and the Pole star is identical to our latitude, i.e., the angle between the equator and our position on the globe.



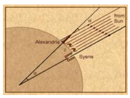


One can also identify one's position by observing the maximal height of the Sun, a specific position proper to each day of the year for a given latitude. In short, if one knows the day of the year, one can find one's latitude by consulting an almanac. What is true for the Sun is equally true for other heavenly bodies of which one can measure the altitude. Latitudes are expressed in 90 degrees from the equator to each pole.

For longitude, things are far more complicated. First, one uses, as Ptolemy did before, a network of lines running from pole to pole, the meridians. As a reference point, by convention, mankind chooses a particular meridian running through a location. Ptolemy had his 0 meridian run through the Canary Islands; others took the island of Rhodes or cities such as Jerusalem or Paris.

Today, the Greenwich meridian is used as the 0 meridian for the time zones. Starting from any chosen 0 meridian, one can count 180 degrees west and 180 degrees east. If one divides the circumference of the Earth into 360 degrees, one can say that each degree represents 111.319 km on the Equator, each minute (one sixtieth of a degree) 1.85 km, and each second (one sixtieth of a minute) 30 meters. As an example, Brussels in Belgium is on 50°51′0″ north and 4°21′0″ east.

The Lesson of Eratosthenes



In the 3rd Century BC, Eratosthenes had discovered that during the summer solstice, the Sun's rays penetrated into a deep pit in Aswan because they were vertical above this location, while at the same instant, in Alexandria, an obelisk threw a shadow.

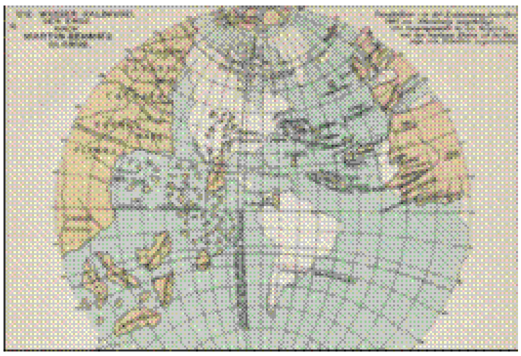
Already in the 3rd Century BC, Eratosthenes had calculated the circumference of the Earth with remarkable precision. He had discovered that during the summer solstice, the Sun's rays penetrated into a deep pit in Aswan because they were vertical above this location, while at the same instant in Alexandria, an obelisk threw a shadow. By measuring the angle (7.2 degrees) between the obelisk and the shadow in Alexandria and the distance between the two cities (5,000 stades (Greek unit of length) of 157.5 meters equals 787.5 km), Eratosthenes concluded that the circumference of the Earth (360 degrees) was equal to 250,000 stades (50 times 7.2 degrees, or 50 times 5,000 = 250,000 stades), or 39,375 km, a calculation very close to the real distance, which is 40,075.02 km.

How the American Continent Saved the Life of Columbus

To document the difficulty of defining longitudes, let us take an example. Unfortunately, the Italian humanist Paolo Toscanelli, a close friend of Nicolas of Cusa, on his map sent to Christopher Columbus made a major error in his calculations respecting the distance separating Europe from Cathay (China) when sailing west to reach the East.

In reality, Toscanelli inherited his error from Ptolemy in the latter's underestimation of the circumference of the Earth. Besides Ptolemy, also Marco Polo had overestimated the size of the Eurasian continent. These wrong distances, and the absence of the American continent, appear on the oldest globe we know of in Europe, produced by Martin Behaim in Nuremberg only a couple of months before Columbus' trip to America in 1492.

The map reproduced here is considered equal to the one presented by Martin Behaim on his 1492 globe constructed shortly before Columbus' trip. One clearly identifies how "close" Asia was thought to be with Europe. The presence of the American continent (in white on the map) gives an idea of the real distances.



The Asian continent spreads across 225 degrees, which brings Europe much closer to Asia. The position of Cipango (Japan) finds itself located on the position of Mexico. One could say that Ptolemy's error "convinced" mariners to take the risk to travel to the East by sailing west.

Toscanelli ends up, on the basis of Marco Polo's reports, to misevaluate the distance between Lisbon and Asia at 6,500 nautical miles or 9,600 km. Columbus cross-checked Toscanelli's measurements with those done in the 11th Century by Al-Farghani (Latinized as *Alfraganus*). This Persian astronomer estimated that on the Equator, 1 degree of the 360 degrees of the Earth's circumference represented something less than 57 miles and that therefore the circumference of the Earth would be about 20,400 miles.

It is here that Columbus made another error. While Al-Farghani used Persian miles of 1,973.5 meters, Columbus translated the distance into Roman miles of 1,481 meters. Hence, for Columbus, the Earth's circumference measured only 30,000 km, some 10,000 km less than for Al-Farghani. Considered from that standpoint, the unforeseen existence of the American continent, missing from Toscanelli's map, saved the life of Columbus.

In principle, the solution to our problem is relatively simple. A full rotation of the Earth takes 24 hours, which means that in 4 minutes, it rotates by 1 degree. To know the longitude of any location, it is sufficient to compare local time with the time of the meridian of reference. Four minutes difference means we are at 1 degree of distance from the meridian of reference.

If the local time measured is in advance, it tells us we are to the east of the meridian of reference, while if we are later than the latter, we are to its west. Defining one's local time aboard a ship is relatively easy by watching the altitude of celestial bodies such as the Sun, which reach their highest position at noontime.

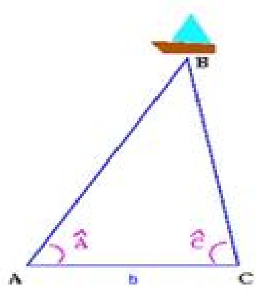
However, to know the time "happening," at the same moment, in another location, in this case the meridian of reference, one needs a clock regulated on that time.

In 1530, Frisius will be the first to conceptualize this solution. From there on, space, to be measured, cannot any longer escape the time factor. The problem was that in Frisius' day, no clock was sufficiently precise to use his method. It will take centuries and a lot of work by Colbert and Huygens to succeed in building such clocks at the French Academy of Sciences. In 1761, the British clock builder John Harrison constructed the first marine chronometer, which allowed the method developed by Frisius.

With Triangulation, Topography Becomes Science

Frisius made another major contribution to modern science. In his*Libellus de locorum describendorum ratione*, a little booklet of only 16 pages published in 1533, Frisius describes how to use triangulation, a method already used by his contemporary Jacob of Deventer and described by the Nuremberg mathematician Regiomontanus (1436-1476) in his *De triangulis omnimodis libri quinque* published in 1533, i.e., only a half century after the death of the author.

The principles of triangulation were discovered by the Greek scientist Thales of Miletus who employed it to measure the distance separating a ship from the coast.



Up till now, we have seen how the science of angles, by comparing proportions, can be very useful. Now, with triangulation, one can go “beyond” angles themselves and, on the basis of the properties of triangles, “discover” distances otherwise unknown to simple sense perception.

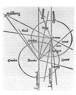
Triangulation was developed by the Greek scientist Thales of Miletus who used it to measure the distance of a ship from the coast line by measuring the angles from two viewpoints of reference whose distance from one to the other is a known distance. Triangulation employs the law of cosines (Pythagoras) and sines and the fact that the sum of the angles of a triangle equal 180 degrees.

At the center of this astrolabe rebaptised “full circle” (volcirkel), Frisius put a compass. The astrolabe that guided so many ship farers now became a useful tool on land.

If today many techniques have replaced these mathematical calculations, triangulation is still used by the military when no radar systems are available.

In his booklet, Frisius shows himself to be a good pedagogue. To start a demonstration, he first says one should draw circles and their diameter on separated sheets of paper. Then he climbs on the top of a high building, let’s say the cathedral of Antwerp. From there, Frisius will use his simplified astrolabe, rebaptized “full circle” (*volcirkel*) horizontally. At its center he will put a compass. In this way, as we will see, the same astrolabe that guided so many ship farers now becomes a useful tool on land.

With this instrument, the observer can orient the diameter of his circle on the sheet of paper parallel to the North-South axis indicated by the compass. As a matter of fact, he aligns the diameter with an “imaginary” meridian. Now he is able to measure the angle between this meridian and the bell towers of other cities he sees from the elevated viewpoint where he stands.

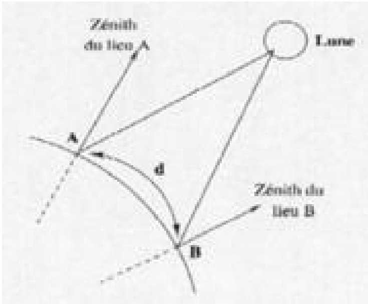


To make a topographic study, Frisius first drew circles and their diameters on separated sheets. He then climbed on the roof of a high edifice, let’s say the Cathedral of Antwerp, to measure the angles between the bell towers of other cities he could see and the North-South meridian indicated by his compass. He then went to the cities he had seen from Antwerp and climbed on the bell towers of the cities he had observed in order to *repeat the same operation. Back home, Frisius puts the different sheets together and connects the “harmony” of the angular proportions. By extending the lines of the different directions he finds the exact location of the cities on the intersection of the lines.*

The example given by Frisius is merely pedagogical because it is impossible to observe the cities he indicates on his graphic. But let us accept his proposition. From Antwerp, at the center of the circle on top, we can “see” the cities of Middelburg, Gent, Brussels, Mechelen, and Lier.

Now Frisius goes to those cities he had seen from the top of the Cathedral of Antwerp and climbs on their bell towers to repeat the same operation. Back home, Frisius puts the different sheets together and "connects" the angular proportions. By extending the lines of the different directions he finds the exact location of the cities on the intersection of the lines. In his example, by fixing the distance between Antwerp and Mechelen at four units of distance, he now can calculate all the distances among the cities he saw.

Triangulation became a method to measure the distances between planets.



The simplicity of this method became very successful. When Jean-Baptiste Colbert creates the Academy of Sciences in 1666, he is convinced that better maps will allow a better management of the Kingdom of France.

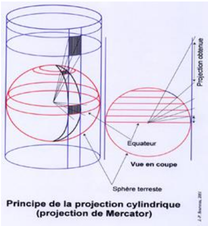
Abbot Jean Picard, one of the cofounders of the Academy, will use Frisius' method as reworked by Snellius to elaborate very precise maps of France. Picard also improves Frisius' full circle by adding a small telescope. As proven here, the spinoffs of nautical and astronomical research immediately helped man to increase his mastery over his immediate environment.

Mercator: From Prison to Glory

In 1544 Mercator spent seven months in this prison (Tower of the Castle of Rupelmonde) accused of not fully subscribing to Aristotelian dogma.

Accused of heresy in 1544 but set free seven months later, Mercator and his family leave Antwerp and Flanders in 1552 to settle in Duisburg, at that time a small town of 3,000 inhabitants. While living there, the cosmographer keeps in touch with the Antwerp master printer Plantin, who has a monopoly over the sale of Mercator's maps throughout Europe and regularly supplies him with quality paper.

It is in Duisburg that Mercator will elaborate in 1569 his first conformal map projection. While all the distances on his map are distorted (for example, the size of Greenland appears bigger than South America), all angles are preserved. While architects and geometers prefer equidistant maps (1 cm on the map equal x cm in reality), Mercator's projection became the standard map projection for nautical purposes because of its ability to represent lines of constant course, known as rhomb lines or loxodromes, as straight segments that conserve the angles with the meridians.



On his 1569 world map, Mercator clearly indicated his geometrical method of projection: from the center of the sphere, all points of its surface are projected on a cylinder, which once unfolded becomes a flat map.

When Mercator publishes his map in 1569, Walther Ghim, his neighbor in Duisburg, describes him as "a man with calm temperament of extreme candor and sincerity." About the map, Ghim writes that "Mercator wanted to allow scientists, travelers, and sea farers to see with their eyes a precise description of the world in large format, projecting the globe on a surface thanks to an adequate means to do so which corresponds so heavily to the squaring of the circle that nothing seemed to be missing, as I heard it from his own mouth, if it were not the formal proof."

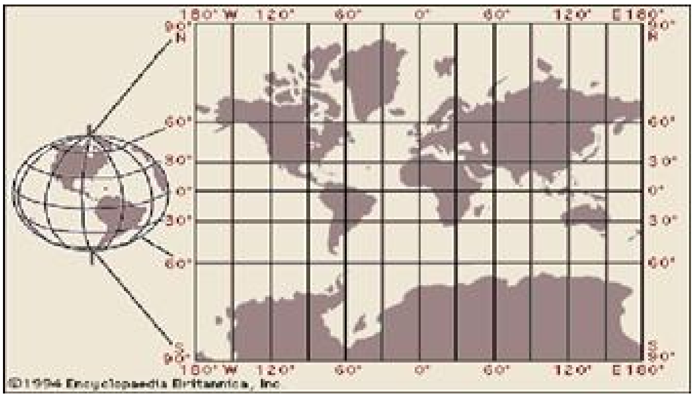
What Greek Scientists Dreamed of, Mercator Realized

What Greek scientists had dreamed of, and what Frisius had set out as the major challenge for science in his time, was partly solved by Mercator 14 years after the death of his teacher.

In his *De Astrolabo Catholico* (*On the Universal Astrolabe*, Anvers, 1556), Frisius writes:

"It is nevertheless possible … to work out a description on a flat surface showing us, on the surface the same things we apprehend otherwise in three dimensions. This artifice, it are the painters which show it to us each day, and Albrecht Dürer, the noble painter and mathematician, put into writing some very beautiful examples in this respect. In effect, he teaches how on a flat surface, which he considers a window, any object can be described as they appear to the eye but in two dimensions.
*" … Ptolemy followed similar principles in the first book of his*Geography*, chapter 24, whose title is 'How to draw on a surface a map of the inhabited world which is in harmony with its aspect on the sphere.' Also in book VII, he proposes the same thing even more clearly in the following terms: 'It isn't inopportune to join some directives how to draw as a surface the hemisphere we see and on which is located the inhabited world, surrounded by an armillary sphere.' In these passages, Ptolemy teaches three or four methods to transform the surface view of the inhabited world on a surface, in such a way that the representation is as conform as possible or similar to what is described on the surface of a spherical form, as is the surface of the Earth, as we demonstrate.*
"… There exist several other methods to describe the circles of a sphere on a surface … all aim at the same purpose, but some get closer to spherical proportions while others stay far away from them. And even if Ptolemy affirms in the first book of Geography *that it is impossible that all the parallel lines maintain the relationships which exist on a globe, it is nevertheless possible that all parallel lines do conserve their relationships they have among them and with the equator.…"*

While with the Mercator projection all the distances are distorted (for example, the size of Greenland appears bigger than South America), all angles are preserved. While architects and geometers prefer equidistant maps (1 cm on the map equal x cm in reality), Mercator's conformal projection became the standard map projection for nautical purposes because of its ability to represent lines of constant course, known as rhomb lines or loxodromes, as straight segments which conserve the angles with the meridians.



But Frisius, who seemed to share Nicolas of Cusa's convictions on the squaring of the circle, insists on the fact that no projection of a sphere on a flat surface can ever conserve *all* the properties of the sphere:

"But I only want to warn about the following: everything we said here about the description on a flat surface will be imperfect when examined in detail. Since never one will ever be able to represent regions in a manner satisfying in all aspects, even if Ptolemy came back. As a matter of fact, either longitude or distance wouldn't be respected, or location neglected, or even both elements would lack, because there isn't any affinity between the sphere and the surface, in the same way that it doesn't exist between the perfect and the imperfect, the finite and the infinite" (Postface to his 1540 *Libellus* on topographical triangulation).

While it is proven that Mercator was familiar with the writings and ideas of Nicolas of Cusa, both the scientific method and the solution discovered by Mercator, i.e., based on a concept of harmony between the sphere, the cylinder, and the surface, are generally presented as a mystery or the fruit of mere hazard, because the mathematical equations to calculate the Mercator projection were only developed much later. What we know for certain is that the "religious" Mercator, just as Kepler and Leibniz, was deeply convinced that the universe was nothing but a reflection of a pre-established harmony and a divine creative principle.

Mercator wrote, for example, that *"wisdom is to know the causes and finalities of things that one knows best through the fabric of the world, magnificently filled and conceived by the wisest architect according to the causes inscribed in their order."*

"I have the particular pleasure to study the formation of the world as a whole," he wrote in a dedication. *"It is the suspended orbit of the Earth,"* he continued, *"which contains the most perfect order, the most harmonious proportion, and the singular admirable excellence of all things created."*

The challenge represented by intercontinental voyages at his epoch is comparable to interplanetary travel today. A rebirth of the enthusiasm and love for the good of Mercator and Frisius are therefore one of our immediate priorities.

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Footnotes

[1] In *De Leuvense hoogleraar Gabriel Mudaeus (1500-1560) als Europees humanist en jurist* (Catalogue de l'exposition *Recht uit Brecht*, 2011), professor Jan Pepy outlines the international influence of Erasmus' Three Language College: "After their studies, former pupils of the Three Language College became professors at at least 27 European universities.… The list of eminent scientists or inventors having successfully employed the new method in their field is impressive." There follows a list of names: Willem Lindanus (exegeses); Hubertus Barlandus (medicine); Viglius van Aytta (History of Law); Juan Luis Vivès (pedagogy); Gemma Frisius (scientific instruments, geography, inspirer of Mercator); Cornelis Kiliaan (lexicographer); Lambertus Hortensius, Johannes Sleidanus, and Nicolaus Mameranus (historians); Antonius Morillon, the Laurinus brothers, and Augerius Gislenius Busbecquius (historiography); Andreas Masius (orientalist); Joris Cassander (liturgy); Jan de Coster and Jan Vlimmer (history of the church fathers); Stephanus Pighius and Martinus Smetius (epigraphy); and Rembert Dodoens and Carolus Clusius (botanics). Professor Papy underlines that "To conclude, Vesalius' breakthrough [in anatomical science] would have been unthinkable without the philological spirit of Erasmus. Although Vesalius was not a direct pupil of the Three Language College, he followed classes and was inspired by former pupils such as Jérôme Thriverus. It was his in-depth knowledge of Greek and the philological study of Galen's writings in the original language that led Vesalius on the track of his own investigations and autopsies leading to discoveries in anatomical science. The renaissance of science, as it appears here, has been possible thanks to a renaissance of the science of scientific language." Let it be noted otherwise that the Three Language College was also the model for the creation of the French Collège des lecteurs royaux

(which became later the Collège de France) in 1530 by King Frances I. The creation of the Collège was suggested by the latter's sister Marguerite de Navarre (grandmother of King Henri IV), a fervent reader of Erasmus and crucial protector of François Rabelais.

[2] One considers the works of Petrarch, Lorenzo Valla, Bessarion, Nicolas of Cusa, and later, Erasmus of Rotterdam.

[3] In particular by the humanist and musician Rudolph Agricola and the excellent pedagogue Alexander Hegius.

[4] The Three Language College was founded thanks to a financial contribution of Erasmus' friend, Jerome of Busleyden.

[5] Frisius teachers were the German philosopher Rudolph Goclenius (Latin), the Flemish printer Rutgerus Rescius (Greek), and Johannes Campensis (Hebrew).

[6] This was not an original invention of Frisius. The use of a dark room to register solar eclipses was already described by the French scientist Guillaume de Saint-Cloud. In 1290, the latter described in his *Almanac*, written at the demand of Queen Mary of Brabant (1260-1321), how to use such a device to procure visual comfort to the viewer: "To avoid this accident [the blinding of an observer studying the solar eclipse of June 5, 1285] and in order to follow it without danger at the hour of beginning, of its end, and the scope of the eclipse, one shall make use of it under the roof of a closed house, or in the window, be it of the size of a whole made in a barrel to extract wine of it. The light of the sun entering by this orifice, to be displayed at a distance of 20 to 30 feet of something flat, for example, on a wooden board, and one will see in this way a beam of light draw itself in a round shape even if the overture is imperfect. The spot of light will be bigger as the hole is bigger and will be further away; but in that case it [the beam of light] will be weaker than if the board is nearer.… The center of the Sun going through the center of the hole, the beams of the superior border will be projected on the lower part of the board." (Bibliothèque Nationale, Mss. 7281, fonds latin, folios 143 verso et 144 recto).

[7] At the Brothers of the Common Life of 's-Hertogenbosch, Mercator's key teacher was Georgius Macropedius (1487-1558), an erudite scholar, Erasmus correspondent, and dramatist who used theater plays to train his pupils. Some of his comical plays inspired the great William Shakespeare.

[8] This process started as soon as 1521 when Erasmus' friends, fearing the Inquisition would kill the beloved humanist, convinced him that it was wiser for him to operate out of Basel, Switzerland.

[9] Albrecht Dürer, *Instructions for Measuring with Compass and Ruler*, 1525.

[10] The Portuguese explorer Vasco da Gama, once having passed the Cape of Good Hope in 1487, went on land to construct a giant astrolabe in order to define with precision the latitude of where he stood.

[11] Because the magnetic North Pole is not exactly in the same place as the geographical North Pole, Mercator, who had his portrait done with a ruler in his hand pointing to an island that one believed to be the pole of the earth's magnetic field, hoped he could use this

physical anomaly to find a simplified solution to solve the problem of longitudes.