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History of Math

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Leonardo da Vinci

Leonardo da Vinci was born on April 15, 1452 in Anchiano, Tuscany, or present day

Italy. Born out-of-wedlock, he was the son of Caterina, a peasant, and Messer Piero da Vinci, a

Florentine notary. While he was still young, his mother Caterina wed another man and started a

new family. Thus, he was raised by his father and his stepmothers. Leonardo spent his early

years in Achiano until the age of five, and then moved to his father's estate in Vinci. Leonardo's

surname "da Vinci" simply means "from Vinci," referencing this fact.

Leonardo received very little formal education, only learning basic reading, writing, and

mathematics. His early life has been subject to historical conjecture. However, Vasari, a 16th

century biographer of Renaissance painters, recalls a story of a peasant requesting his father to

paint his shield. In turn, Leonardo painted it with a monster spitting fire, which was so horrifying

that Messer Piero had to sell the shield and buy a new one for the peasant (Wikipedia). At around

the age of 14, da Vinci's father apprenticed him to a renowned Florentine painter, Andrea del

Verrocchio. At Verrocchio's workshop, Leonardo learned many skills, and amongst these skills

were metalworking, mechanics, drawing, carpentry, sculpting, and modelling. The painting

Baptist of Christ is said to be the product of a joint effort between the master and apprentice. Due

to being an illegitimate child, or a "bastard," a stigma was attached to Leonardo. In order to gain

power and achieve a respectable position, he sought entry into the guilds. In 1472, at the age of

twenty, Leonardo qualified as a master painter at the Guild of Saint Luke in Florence. However, even though he established his own workshop, he still worked with his master Verrocchio for five years. Then, da Vinci and three other men were accused of sodomy in 1476. While they were acquitted, no one knows his whereabouts for the two years that followed.

In 1482, Lorenzo de' Medici, the ruler of Florence, requested Leonardo to make a silver lyre in the shape of a horse's head as an offering of peace with Ludovico Sforza, ruler of Milan. During this time, Leonardo sent Sforza a letter, bragging about his artistic skills, but more so his ability as a military engineer. Sketching pictures of war machines, the letter seemed to have worked as Sforza brought da Vinci to Milan and hired him in 1482. Having relocated to Milan in 1482, da Vinci began to work for Sforza not only as a military engineering advisor, but also as a sculptor and painter.

Due to his vast knowledge and curiosity in many subjects, including anatomy, music, mathematics, painting, history, and cartography, Leonardo da Vinci exemplified the definition of a "Renaissance Man." Like many leaders of the Renaissance humanism, Leonardo didn't believe that art and science were mutually exclusive; rather, they were intertwined with one another. Da Vinci once wrote "a good painter has two chief objects to paint -- man and the intention of his soul. The former is easy, the latter hard, for it must be expressed by gestures and the movement of the limbs," accomplishing the latter by studying anatomy and dissecting human and animal bodies (Biography).

During his time in Milan, Leonardo worked on many projects. In 1483, he was commissioned to paint *Virgin of the Rocks* by the Confraternity of the Immaculate Conception and in 1495, he was commissioned by Sforza to paint *The Last Supper* for the monastery of

Santa Maria delle Grazie (Wikipedia). However, at the start of the Second Italian War in 1499, Sforza was overthrown. Leonardo and his friends, which included Luca Pacioli, an Italian mathematician, fled Milan for Venice. There, da Vinci was responsible for devising plans to protect the city from naval attacks. Shortly after, he returned to Florence.

With his return to Florence in 1503, da Vinci began work on *Battle of Anghiari*, a mural commissioned for the city council of Palazzo Vecchio, and *La Gioconda*, or more commonly known as the *Mona Lisa* (Biography). While the *Battle of Anghiari* was abandoned after two years, the *Mona Lisa* would become one of the most famous paintings in the world.

In 1506, Leonardo returned to Milan and worked for Gian Giacomo Trivulzio, who had defeated Sforza just seven years prior. However, due to political tensions, Leonardo once again left Milan for Rome with his friend Salai. In October of 1515, King Francis I of France recaptured Milan. Subsequently, Leonardo was commissioned to make a mechanical lion that would have the ability to walk over and open a chest full of lilies for Francis I (Wikipedia). In fact, da Vinci was present when Francis I and Pope Leo X met at Bologna in December of 1515. In the next year, da Vinci would be under the service of Francis I, given access to the Clos Lucé, a chateau. Leonardo spent the last years of his life here with his friend Count Francesco Melzi. During this time, he also became friends with Francis. Leonardo died on May 2, 1519 at the Clos Lucé and it is said that he died in the hands of the king.

While Leonardo is mostly known for his paintings, being the "Renaissance Man" that he was, he had interests in other areas of study as well. Thus, his paintings not only show his artistic ability, but these other studies as well.

As stated earlier, *The Last Supper* was painted during da Vinci's stay in Milan under Sforza's rule. The painting depicts the last scene of Jesus Christ and his twelve disciples, seconds after he announces that he will be betrayed by one of them. With Jesus Christ in the center of the painting, and the rage, shock, and confusion displayed by his apostles, the center literally and figuratively falls onto Jesus Christ. Indeed, Christ's body forms an equilateral triangle. In addition, he serves as a single vanishing point for the painting. A vanishing point is a point
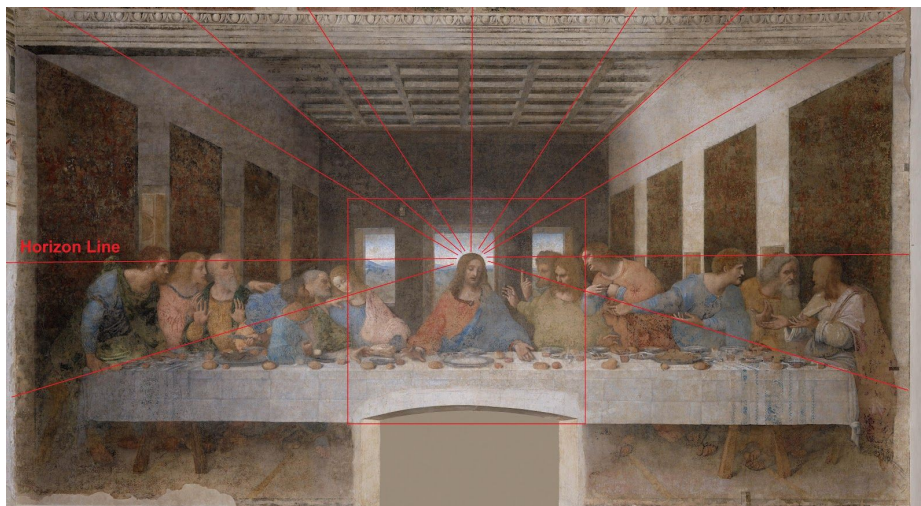
where extensions of parallel lines appear to converge in a perspective drawing (Wolfram). As seen in the picture to the left, there are a series of parallel lines stemming from the corridors and even the ceiling that converge at Jesus Christ's head, or more specifically, his right eye. Since all the lines converge to one point, there is a single vanishing point. The number *n* of vanishing points corresponds to the picture or painting being in *n*-point perspective. Thus, *The Last Supper* is in one-point perspective. Indeed, Leonardo was a pioneer in one-point perspective and used it extensively to create more realistic and natural paintings (ArtMumble). The concept of a vanishing point is also an important subject in the field of projective geometry.

In 1497, Luca Pacioli composed the book "De Divina Proportione" (The Divine Proportion) and Leonardo drew illustrations of regular solids for it when he lived and learned mathematics from Pacioli (Wikipedia). These illustrations were important because they were the first to be in the shape of "solid edges" rather than simple line drawings (Hart 1999). Published in 1509 in Venice, Pacioli wrote about mathematical and artistic proportions, especially that of the Divine Proportion and how it functions in mathematics, architecture, and art. Indeed, on the first page of the book, Pacioli writes:

> "a work necessary for all the clear-sighted and inquiring human minds, in which everyone who loves to study philosophy, perspective, painting, sculpture, architecture, music and other mathematical disciplines will find a very delicate, subtle, and admirable teaching and will delight in diverse questions touching on a very secret science" (Meisner 2014).

Da Vinci would later call the Divine Proportion "sectio aurea," or Golden Section in Latin. Today, this proportion is most commonly known as the Golden Ratio.

Two quantities are said to be in golden ratio if the ratio of the sum of the two quantities to the larger quantity is equal to the r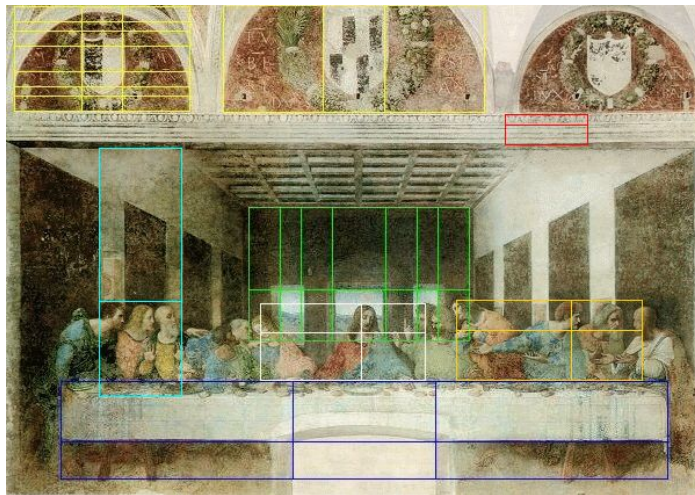atio of the larger quantity to the smaller quantity. Algebraically, if a and b are quantities such that $a > b > 0$, then if $\frac{a+b}{a} = \frac{a}{b}$, then a and b are in golden ratio. This ratio is denoted by phi, or $\varphi = \frac{1+\sqrt{5}}{2}$ and approximates to 1.61803…. In addition to the Divine Proportion and the Golden Section, some other names for the Golden Ratio include the Golden Proportion and the Golden Number. It should be noted that even

though Pacioli wrote about the Divine Proportion, he was not the first to discover it, as the concept was first mentioned by Euclid in his *Elements*.

There are many shapes that can be derived using the golden ratio. Two of them are the golden rectangle and the golden triangle. The golden rectangle is a rectangle whose sides are in the golden ratio; the golden triangle is an isosceles triangle where the ratio between a side and the base are in the golden ratio. The Golden Ratio is called golden because it is deemed the most balanced and aesthetically pleasing proportion -- the perfect proportion (Wolfram).

If we return back to *The Last Supper*, we can see that da Vinci dabbled with subtle uses of the Golden Ratio. Observe how the painting below has multiple golden rectangles about the whole piece. Not only do they serve aesthetic purposes, but they also show da Vinci's use of geometry to once again center the piece around Jesus Christ.

Perhaps the most famous of Da Vinci's paintings is *La Gioconda*, or the *Mona Lisa*. The painting is said to be a portrait of Lisa del Gioconda, the wife of the wealthy Florentine silk merchant, Francesco del Gioconda (Biography).

Mona Lisa derives its name from "Mona," an Italian word of addressing someone in a similar light to "my lady" and the subject of the painting, Lisa Gioconda. While da Vinci started working on this painting in 1503, it is thought that he worked on it as late as 1517. This was

likely a result of him wanting the painting to literally be perfect. When Leonardo died in 1519, it was inherited by his friend Salai, and subsequently fell into the possession of King Francis I.

One of the most defining features of the *Mona Lisa* is the enigmatic smile that the subject portrays. The horizon is placed at the neck rather than the eyes, and in conjunction with the lack of human presence in the background, it adds to the mysterious nature of the painting (Wikipedia). However, like all of da Vinci's works, it is no coincidence that the painting would be appealing to a large audience. On closer analysis, da Vinci heavily utilized the golden ratio on this painting as well. As seen below, notice how the subject of the portrait is enclosed, or more precisely, painted in the shape of the golden triangle. This attracts thoughtfulness to her face as it is positioned towards the top of the triangle. In addition note the golden rectangles present in the
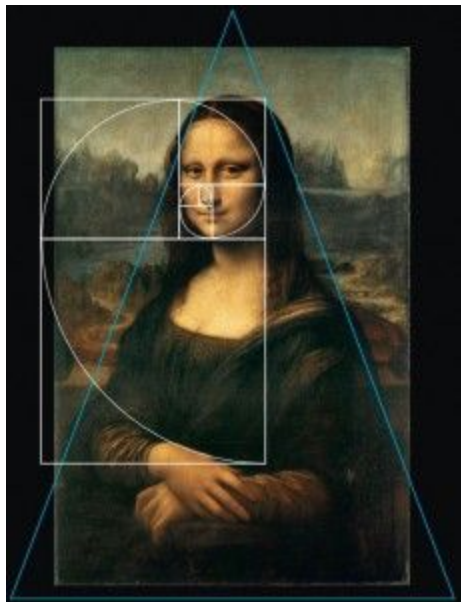
painting. More specifically, there is a golden spiral present. The golden spiral goes through the corner of squares in a golden rectangle; it is a logarithmic spiral with a growth factor of the golden ratio (Wolfram). As seen in the picture on the left, the golden spiral perfectly spirals her face. The use of the Golden sections in this piece send a subliminal message; one that is harmonious, balanced, and beautiful. As an avid user of the golden ratio, Leonardo da Vinci paved the way for future artists that used the same concept such as Michelangelo and Raphael (Meisner 2014).

While Leonardo da Vinci is known for his art, he is actually given credit to less than two dozen paintings. As a Renaissance man, he delved into other subjects. Da Vinci was a

mathematical genius that used other fields of study in his art including, but not limited to proportion, geometry, anatomy, and perspective. Though he was poorly educated and considered a bastard, he did not let those things obstruct him from his true potential. It is important to realize that Leonardo da Vinci not only made great advances in art, but also those in mathematics as well.

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