Was Leonardo da Vinci a 'Copernican'? Leonardo's Astronomical Thought in Context

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Abstract. There are tantalizing notations in Leonardo's notebooks indicating that he thought the sun was the centre of the solar system. At the same time, his thought contains remnants of Aristotelian physics and traditional medieval notions of geology and atmospheric science. This paper will describe the evidence from paintings, sketches, and notes, and it will examine the assumptions behind the question of Leonardo's heliocentricity. What exactly does it mean to say 'the sun does not move'? Leonardo's astronomical writings show a penetrating curiosity and prescient instincts which are often confirmed by subsequent discoveries. This paper will examine the interpretive techniques we use on this greatest of Renaissance masters, and suggest a perspective on his astronomical writings that is consistent with the rest of his natural philosophy.

'Copernican' before his time?

What are we to make of these five words, written by Leonardo da Vinci in the upper left corner of a sheet of paper in the Windsor collection around 1510? 'Il sole no si move' (The sun does not move).[1] (Fig. 1) Are these words, as Walter Isaacson put it, 'a brilliant leap decades ahead of Copernicus, Galileo, and the realization that the sun does not revolve around the Earth?'[2] If so, it would confirm many of our inclinations about Leonardo, that he was almost supernaturally perceptive in his studies of nature. The sentence is

[1] The words appear in the upper right corner of Windsor RCIN 912669v. A standard reference is Jean Paul Richter, *The Notebooks of Leonardo da Vinci*, 2 volumes (New York: Dover Publications, 1970), p.139, or J.P. Richter 865.

[2] Walter Isaacson, *Leonardo da Vinci* (New York: Simon and Schuster, 2017), p.441.

Richard Poss, 'Was Leonardo da Vinci a "Copernican"? Leonardo's Astronomical Thought in Context', *Culture and Cosmos,* Vol. 27 no. 1 and 2, Spring/Summer and Autumn/Winter 2023, pp. 43-52.
www.CultureAndCosmos.org

often quoted with much solemnity, and it is noted that the letters are twice as large as anything else on the page, suggesting the gravity of the realization. This paper will examine the statement in the context of Leonardo’s other astronomical writings and consider what weight should be given to the mystique of Leonardo, and whether we should credit him with a full-blown heliocentric theory.

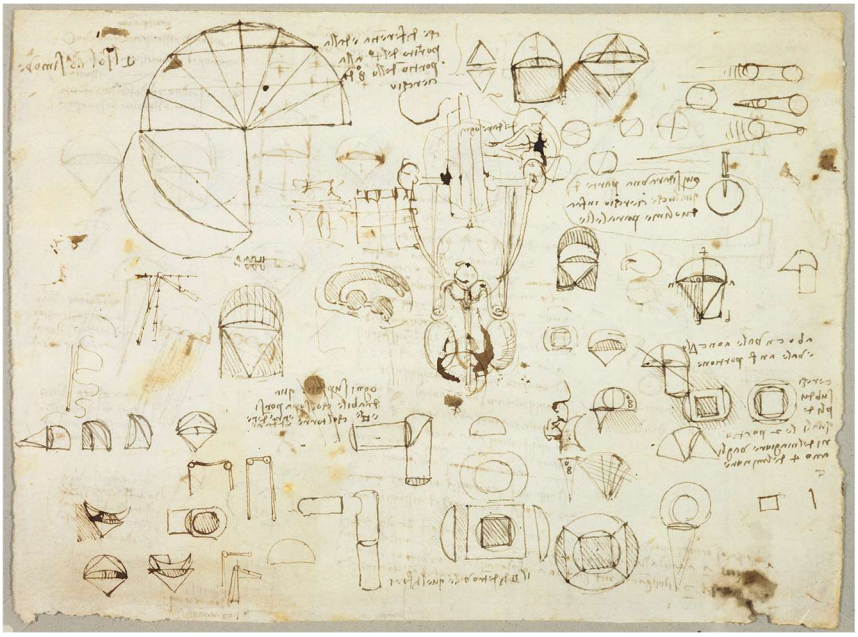

Fig. 1. ‘Il sole no si move’ (The sun does not move), in the upper left- hand corner. From the Windsor Collection, Windsor RCIN 912669v.

Leonardo’s education

Leonardo was the epitome of the ‘Renaissance Man’. As one of the three foremost artists of the Italian High Renaissance, along with Raphael and Michelangelo, he occupies a dominant position in art history. At the same time he generated new insights, new techniques, and new inventions in every field from mechanical engineering to plant science, including anatomy, physiology, weapons, geology, and astronomy. However, his working practice was such that most of this material was lost to society for hundreds of years.

Leonardo's education was ideal for the practicing artist but lacking for the scholar. At the age of fourteen he was apprenticed to the workshop of Andrea del Verrocchio, a successful Florentine artist who received numerous commissions from the ruling Medici family. So, Leonardo did not learn Latin, did not study the Bible or Aristotle. Rather, he learned how to draw in that pure Italian Renaissance fashion of rendering. From that beginning he learned all the activities of a thriving early Renaissance workshop: to paint, to carve wood, to do sculpture in marble and bronze, and to design architecture. Leonardo's career coincided with the industrial production of paper, which was plentiful and inexpensive. Everything begins with a sketch, and he seemed to develop the ability to think on paper. His surviving designs and drawings, some large, some bound in volumes, include a bewildering variety of subjects, with pages on mathematics, geometry, and studies of optics, including lenses and mirrors. There are pages of drawings from life of dissections Leonardo made of all parts of the human body, male and female, as well as horses, cows, and birds. Also present are cryptic comments, riddles, fables, brainstorming and psychological self-analysis.

Notebooks and drawings

It is estimated that Leonardo produced over 20,000 pages, of which about 7,000 pages survive. After he died, the notebooks were bought and sold as collectibles, but not studied for their content, and today they reside in the collections of Europe's greatest museums. It is not unusual to find several subjects on the same sheet of paper. 'The sun does not move' appears alongside a cross section of the brain, geometrical diagrams, mathematics, a drawing of the male urinary tract, and various doodles.

Many sheets contain preparatory sketches and studies for works of art, like the Last Supper. He would have models in the studio in various poses as he worked through the design of a painting. There are drapery studies, a major preoccupation for the fifteenth century artist, to convince the viewer that there was a body inside that drapery, pushing out on it and carrying weight. These relate to his drawings of spherical bodies reflecting light in reference to eclipses. Leonardo was a military engineer, and his pages show designs of fortifications, architectural designs for defences, and a great variety of weapons. In designing new weapons, he would take the device as it existed in his time and enlarge it, or multiply it, to create a super-

sized version of the weapon. Not all these designs were practical, and most were never built, but they show a mind eager to leap into the future of technological advance. His justifiably famous futuristic designs include a tank, a hang glider, a flotation device, a device for breathing underwater, a parachute, and a helicopter. In addition, there are drafting designs for industrial machines which are so detailed they contain enough information for one to be built. Architectural designs for central plan churches form part of the conversation that included Bramante and Michelangelo for the new basilica of St. Peters in Rome. Perhaps most famous are his dissections of the human body, where he analyses the flow of blood, the interior organs, and the muscles of the torso, arms, legs, and neck. He dissected the eye, the optic nerve, and its connections with the brain, which he studied in detail. He dissected birds, the wings and the brains, with a view towards flying himself, hurling flying machines off the roof of his house in Florence.

To determine Leonardo's perspective on heliocentricity, it is useful to review his contemporaries and their potential contributions to Leonardo's thinking. Marcantonio della Torre was a professor of anatomy at the University of Pavia. The two of them collaborated on a book of anatomy. Della Torre wrote the text and Leonardo did the illustrations.[3] Leonardo drew over 700 drawings from dissections for this book. But della Torre died of the plague in 1511. Leonardo had to leave the city, and he dropped the project. Thus, we have amazing drawings of the inside of the human body, housed in the Windsor collection. In another case, he injected molten wax into the brain of an ox to determine the shape of its internal cavities, the ventricles. Medical doctors did not arrive at this technique for another 300 years. He drew the reproductive system, the cardiovascular system, and the intestinal system.

Leonardo and astronomy

In astronomy, the prevailing paradigm at this time was the Aristotelian / Ptolemaic geocentric universe.[4] Leonardo, in his notebooks, has specific questions he is worried about. Is the Earth covered more with earth or water? How do you measure the size of

[3] Walter Isaacson, *Leonardo da Vinci*, p.400.

[4] Edward Grant, *Planets, Stars and Orbs: The Medieval Cosmos 1200-1687* (Cambridge: Cambridge University Press, 1996).

the Sun? Why do you find fossils on the tops of mountains? What is the interior of the Earth like? Does the Moon have oceans? Does the Moon give off any light of its own? There was considerable discussion at the time that the Moon might be translucent or even give off some kind of residual light. He studied lenses and mirrors. He admired Archimedes and knew what he was rumoured to have done. Leonardo thought it possible to use mirrors in battle. He also wanted to use them to boil water.

Leonardo's drawings of the Moon, which he did over a hundred years before the telescope, show awareness of the light and dark portions, and his shaping of these areas matches modern photographs.[5] He was interested in how sunlight reflects off of the Moon in different ways to create its varying appearance. On one page, he explained and shows in a drawing how the Sun shines on the Earth, bounces off the Earth to strike the Moon, and then shines back down to the Earth, to produce the effect we call 'Earthshine'.[6] He nailed the cause of this phenomenon, but the page is not published. Much of his astronomical interest is directed to the interactions among the Earth, Moon, and Sun. Tantalizing is this fragment:

> The Earth is not in the center of the Sun's orbit, nor at the center of the universe, but in the center of its companion elements, meaning earth, air, water, fire and so on. Anyone standing on the Moon when they're in the Sun or both beneath us would see this our Earth and the element of water, just as we see the Moon and the Earth would light it as it lights us.[7]

Like many of his writings, this shows Leonardo actively considering alternative arrangements of the Earth, Moon, and Sun, and willing to explore changes in perspective. The question is whether he has evolved a coherent map of the system, an alternate cosmology, when, for instance, he wrote: 'Let the earth turn on whichever side it may. The surface of the water will never move from the spherical form,

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[5] Codex Atlanticus f674v. See also Alessandro Bettini, "Did Leonardo Invent the Telescope?", *Optics and Photonics News*, Feb. 2022.
[6] Claire Farago and Carlo Pedretti, eds., *Leonardo da Vinci: Codex Leicester, a Masterpiece of Science* (New York: American Museum of Natural History, 1996), Sheet 2a, folio 2r, p.47.
[7] J.P. Richter 858, p.137.

but will always remain equidistant from the center of the globe'.[8] Or: 'In my book, I propose to show how the oceans and seas must, by means of the sun, make our world shine with the appearance of a moon'.[9]

He wrote 'in my book,' indicating that he is planning to write a book of astronomy. But he never gets around to it. In a similar fragment, he wrote: 'Memo: That I first must show the distance of the Sun from the Earth; and, by means of a ray passing through a small hole into a dark chamber, detect its real size'.[10] But he fails with that experiment. He is saying that first he will do the distance of the sun measurement, then he will proceed to the larger astronomical book, but he never gets that far.

Finally, a pictorial argument can be made that he did not intend heliocentricity in one of the pages dealing with the Earth, Moon, and Sun. He draws circular arcs which indicate orbits, with the Earth on the left side of the page, the Moon on a circular arc whose centre is the Earth, and the Sun at the right-hand side of the page on a circular arc whose centre is the Earth.[11]

Just as tantalizing is this statement: 'Construct glasses to see the Moon magnified'.[12] This clearly shows that Leonardo thought you could get a bigger and better image of the Moon using lenses or mirrors. Did Leonardo build a telescope? A powerful argument can be made that he did.[13] In my view the evidence is not conclusive, and I remain sceptical. Another fragment reads: 'That the Earth is a star'.[14] This shows again Leonardo's willingness to change perspective, to see the Earth from a distance, to imagine himself in another part of the cosmos and thereby see the heavenly bodies in a way that opens new possibilities. This fragment is like 'The Sun does not move' in that it hints at a major new insight but without evidence or context. All these fragments are on pages where they commingle with different subjects, with plans, jokes, riddles, diagrams,

[8] J.P. Richter 858, p.138.
[9] J.P. Richter 874, p.144.
[10] J.P. Richter 874, p.139.
[11] Farago and Pedretti, *Codex Leicester*, Sheet 7a, folio7r, p.87.
[12] J.P. Richter 910, p.168.
[13] Alessandro Bettini, 'Did Leonardo da Vinci Invent the Telescope?', *Optics and Photonics News* (Feb. 2022): pp.30–37.
[14] J.P. Richter 865, p.139.

preparatory sketches, and recurring images like the 'old man'. The question is, do we credit Leonardo with the Copernican hypothesis on the basis of this material?

Possible influences

Leonardo didn't need to be influenced by anyone to generate a brilliant original idea, but there are several possible influences that were available to him, and he may have been aware of some or all of them. Aristarchus was known to have a heliocentric theory in ancient times, and it is passed down to us by Archimedes, whom Leonardo admired.[15] Copernicus mentions Aristarchus in his *Letter Against Werner* in 1524.[16] In late antiquity, Martianus Cappela devised a universe in which Earth was at the centre, and while the Sun orbits the Earth, Mercury and Venus both orbit the Sun. It is said that Tycho Brahe knew about this and that it may have influenced him. The French philosopher Jean Buridan contested Aristotelian notions of bodies and motion. In particular, Buridan developed the concept of impetus, and in his notebooks, Leonardo does something very similar. Nicole Oresme was a French philosopher, Bishop of Lisieux, and counsellor to King Charles V of France. In the *Livre du ciel et du monde* (1377) he goes through all of the arguments against the rotation of the Earth and refutes them, each in turn. (The heliocentric system requires Earth to rotate.) Having done that, he then wrote that he still thinks the Earth is stationary and it's the heavens that move.[17]

My conclusion is that there were many ideas and theories which, while not purely Copernican, still acted to undermine one or another aspect of the Ptolemaic system, and they were known to intellectuals of Leonardo's time. Nicholas of Cusa was a Cardinal who, in 1444, became interested in astronomy and acquired astronomical instruments. In his writing, he speculates that the Earth might move around the sun, the stars might be other suns, and space might be infinite. Those

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[15] Sir Thomas Heath, *Aristarchus of Samos: The Ancient Copernicus* (New York: Dover Publications, 2004), p.301.

[16] Nicolaus Copernicus, "The Letter Against Werner" in *Three Copernican Treatises*, Trans. By Edward Rosen (New York: Dover Publications, 1959) p.101.

[17] A. Pannekoek, *A History of Astronomy* (New York: Dover, 1961) pp.178-187. Thomas S. Kuhn, *The Copernican Revolution* (Harvard University Press, 1985) pp.100-133.

stars might have worlds, and those worlds might be inhabited. We should remember that Nicholas of Cusa (a high-ranking church official) did this in the mode of abstract, theoretical speculation.[18] While he was safe from scandal, his ideas spread and provided ground for further speculation. One of Nicholas of Cusa's friends was Paolo dal Pozzo Toscanelli, a member of the Medici circle in Florence who was a mathematician and astronomer with broad connections among the Renaissance humanists. Toscanelli made observations of comets and calculations of their orbits and constructed the gnomon at the Florence Cathedral in 1475.[19] It was Toscanelli who wrote to a Portuguese priest that you could sail west and reach Asia, and though nothing came of it, he sent another copy of the letter to Christopher Columbus, who carried the letter with him on his voyage.[20] The Toscanelli - Columbus connection is controversial, and still disputed. The German Renaissance mathematician Regiomontanus published books on astronomy and astrology, and together Peuerbach and Regiomontanus published an epitome of Ptolemy, which Leonardo had a copy of in his library. Lucas Pacioli was a mathematical genius who collaborated with Leonardo. Pacioli did the text and Leonardo did the drawings, and this project was actually completed, and the book, *On Divine Proportion*, was published in 1509.[21]

A Copernicus connection?

What about Copernicus? He studied in Bologna for three and a half years, starting in 1496. He did optical astronomical observations in 1500. He spent a year in Rome lecturing on mathematics and astronomy. He gets a degree in canon law from Ferrara in 1503, then went back to studying in Padua. There he studied medicine, including dissections. Luca Pacioli was teaching there at the same time that Copernicus is a student. While at one point Copernicus and

[18] Thomas S. Kuhn, *The Copernican Revolution*, p.235.
[19] J. L. Heilbron, *The Sun in the Church: Cathedrals as Solar Observatories* (Cambridge, Massachusetts: Harvard University Press, 2001) p.70.
[20] William D. Phillips and Carla Phillips, *The Worlds of Christopher Columbus* (Cambridge: Cambridge University Press, 1992, p.108.
[21] Luca Pacioli and Leonardo da Vinci, *De Divina Proportione* (Venice: Paganini, 1509).

Leonardo were briefly in the same city, Bologna, in April of 1500, it is highly unlikely that they met.[22] The *Commentariolis* is basically a white paper in which Copernicus describes his heliocentric theory. He circulated it in manuscript form before 1514, describing the heliocentric system. Valerie Shrimplin has shown that Copernicus' heliocentric theory was in circulation in Italy before the publication of the *Revolutions* in 1543, and that it wasn't necessary to have read the *Revolutions* to grasp the essentials of the system.[23]

Conclusions:

While Leonardo may have had discussions with some of the thinkers mentioned here, he is as likely to have prompted them to more original thoughts than the reverse. Even with all these ideas in circulation, there is not enough to conclude that Leonardo was a heliocentrist. But there are many modifications of Aristotle and Ptolemy in the air among the intellectuals that Leonardo would have known. We need to be careful that the mystique surrounding Leonardo does not lead us to exaggerate his gifts. His genius is undoubted, his uniqueness is beyond question. His originality in art, mechanics, anatomy, and weapons is amply demonstrated in the notebooks that survive. But we need more than this cryptic statement to conclude that Leonardo was a Copernican.

A hypothetical example might be useful. CalTech is the home of the Einstein papers. Suppose in the papers there was discovered a sheet of paper with a laundry list, and in a corner appear the words, 'the expansion is accelerating', in Einstein's handwriting. On this basis, would you give Einstein credit for having anticipated the discovery of the acceleration of the expansion of the galaxies decades before it happened? I would think not. And why not? You might expect a more detailed explanation, an argument, some data, and some context. Most of all he needs to tell someone, preferably in an article published in a peer-reviewed journal. You would expect this even though he is Einstein, with all his undoubted accomplishments. Leonardo had good reasons for not going to the trouble of publishing his work, mainly because it would have taken time from other

[22] Owen Gingerich, 'Leonardo's Legacy in Science', in Farago and Pedretti, *Codex Leicester*, p.26.

[23] Valerie Shrimplin, *Sun Symbolism and Cosmology in Michelangelo's "Last Judgment",* Sixteenth Century Essays and Studies 46 (Kirksville, MO: Truman State University Press, 2000), pp.255–60.

research that was more interesting to him. He moved from one area to another with astonishing speed, and the social interaction of publishing would have been a drain on his energy. So, while the words ‘The Sun does not move’ engender endless speculation, they must remain mysterious and unresolved.