Focus

Setting Earth free

If you go out into a field under dark skies and lie on your back all night watching the heavens, then it is obvious that the Earth is in the middle of the Universe and all the stars slowly wheel around the Earth through the night. And it is also obvious that during the day, the mighty Sun travels round the Earth. Although we know otherwise today, it is still impossible to produce every day observational evidence that this is not the case.

This month's Focus follows the story of three men who took great steps in walking towards the knowledge that in fact the Earth is not at the centre of the Universe. It must be remembered that these men, Copernicus in particular, were trying to prove something that most people believed intuitively could not be the case. It is a tribute to them that they took their science at face value, even though the science did not always seem to be correct.

In the first article, Allan Chapman writes about Nicholas Copernicus, in the second, Tony Kinder describes the impact of the grand observer, Tycho Brahe, and in the final article, Martin Barraclough continues the story with the life of Johannes Kepler. These three great men slowly began to set Earth free from its static position at the centre of the Universe.

In 1473, when Nicholas Copernicus was born at Torun, Poland, no one thought in terms of astronomical progress. The idea of a science that was for ever expanding and discovering hitherto unimagined realms of knowledge was as far removed from their world view, I suspect, as life in 2533 will be from ours. For even the most educated men of the 15th century saw human knowledge as essentially fixed in scope.

Yes, there were the arts and sciences: music, astronomy, grammar, medicine and the rest, that had come down from classical antiquity. But most people in 1473 would have agreed that the ancients had been incomparably cleverer and more far-seeing than the men of the 'modern age' – the tired, dull-witted runt-end of the human race who awaited Armageddon not long after 1500. For it had been Aristotle, Hipparchus and Ptolemy, between 350BC and AD150, who had worked out the great truths about the Universe, with its spherical Earth in the middle, surrounded by the nine celestial spheres. The first seven of these spheres had carried the Sun, Moon and planets up to Saturn. The eighth sphere carried all of the fixed stars – each of which was at exactly the same distance from the Earth – while the ninth acted as a great flywheel. Heaven itself lay beyond the ninth sphere.

Greek cosmology as it came to be adopted by the Christian church and passed on into the medieval world worked on two levels. Firstly, it explained the qualitative properties of astronomy, such as the nature of light, solar heat, and the intellectual purity of circular orbits. And secondly, it developed a complex mathematical geometry, whereby the peculiarities of observed planetary motions, such as the retrogrades of Mars, Jupiter and Saturn, and the strange mechanics of the lunar orbit could be reconciled with the theory of perfect circular motions.

Claudius Ptolemy's *Almagest* of circa AD150, which first became available in the west in Latin translations based upon earlier Arabic translations of around 1160, constituted the intellectual triumph of classical astronomy when it achieved this reconciliation. And while the Arabs, especially those of Toledo, Spain, refined a few of its details around 1100, this elegant geocentric cosmology was believed to describe both physical and mathematical truths. After all, the Earth was clearly massive and immovable, while the heavens were light and fiery, as was obvious from the upward rising of candle flames and the falling of stones.

Yet thirteen hundred years after Ptolemy's astronomy was first given to the world, it was clear that all was not well. Ptolemy's tables and their medieval Spanish derivatives no longer gave accurate predictions for the planetary positions, while the celestial constants needed to calculate the crucial date of Easter were clearly sliding further into error with each passing century.

In the 1470s, the Nuremburg astronomers Regiomontanus and Bernhard Walther had become the first north Europeans to start re-observing the heavens with large research instruments in an attempt to re-measure the planetary positions and try to square Ptolemy's celestial mechanics with what was actually observed in the sky. Yet it was all so puzzling: could the revered ancients have been mistaken so that mere 'moderns' had to correct them; had transcription errors crept into the various translations, or were the very heavens themselves wearing out as they approached the end of time?

These were some of the problems faced by the twenty-four year old Nicholas Copernicus when he made his first recorded observations – of the occultation of the star Aldebaran by the Moon – in Bologna, Italy, on March 9, 1497. Lunar occulations indeed could be troublesome in so far as

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the wandering orbit of the moon meant that they rarely took place at the times predicted from the standard tables.

Copernicus came from a prominent Polish family, and since his father had died when Nicholas was only ten, his powerful uncle, Lucas Watzenrode, Bishop of Ereland, supervised his education. Late medieval Bishops also tended to be powerful feudal magnates, and this was especially important in Poland where Russian Cossacks and Steppe tribesmen could sometimes sweep in to pillage and sieze territory. The young Copernicus, therefore, grew up in a world of harsh political realities, though he was a very different type of man from his tough and melancholic ecclesiastical uncle Lucas whom, one suspects, he was afraid to cross.

In 1491, he was sent to the flourishing university of Cracow, to begin his higher education, where he would have acquired some familiarity with Ptolemaic astronomy, as one of the seven 'liberal arts' of the medieval BA degree. And while still a student, no doubt assisted by his uncle's influence, Copernicus was installed as a Canon of Fraunburg Cathedral, which provided him with a handsome income for life. Though never becoming a full priest, he acquired life-long commitments to church administration and politics, and remained a devout Catholic down to his death nearly fifty years later.

It is clear that Bishop Lucas recognised his nephew's intellectual gifts, and resolved to make maximum use of them. To complete his education, therefore, he was sent to do post-graduate work in Italy, at a time when the Renaissance was setting European minds ablaze. In 1496, he arrived at the great university of Bologna to study Canon, or Church Law; a very useful subject for a future ecclesiastical administrator.

Yet in addition to his official legal studies, it is clear that he had already become smitten with astronomy, for as we saw, he observed a lunar occultation from Bologna in 1497. No doubt it was being in Italy, and not far from Rome, which made him all too aware of the contemporary errors of the calendar, and he no doubt felt flattered to be consulted about the problem by Pope Alexander VI himself. Indeed, we know that he must have been in Rome on November 6, 1500, for he observed a lunar eclipse from that city, and had already lectured on astronomy.

Nicholas Copernicus 1473-1543. Picture courtesy Dee Levers.

Copernicus returned to Poland in 1501, though he was doubtless delighted to find that the Fraunburg Cathedral Chapter, or governing body, authorised him to return to Italy, to take a doctorate in medicine.

Intellectual Italy

Italy, quite simply, led the intellectual life of Europe in 1500, and did so because of a style of scholarship which had come to flourish there: humanism. During the Renaissance, 'humanism' was not, as the word is often used today, about denying the existence of God, but about the re-discovery of the pure Greek learning of antiquity, and its superiority to the defective Latin translations (often from Arabic intermediaries) that had been circulating in Europe's medieval universities.

And what had triggered this movement was the invasion of the Greek Byzantine Empire by the Muslim Turks in 1453, which caused hundreds of modern Greek scholars to flee west to Italy for sanctuary. And they brought their libraries with them, including 'pure' original Greek texts from Aristotle and Ptolemy, mathematics and neoplatonic philosophy; hundreds of titles, indeed, never previously seen by a Pole or German or an Italian.

Humanist learning, be it in law, medicine or astronomy, hoped to re-capture the first Greek thought, to inject ancient insight into befuddled modern minds. It was a radically different conception of knowledge from that which we have today, where new experiments and fresh observations are seen as the natural way forward. Yet this is why the Bishop and Canons of Fraunburg Cathedral were willing to let Copernicus spend so many years in Italy, for the Greek humanism that he would imbibe should make him a wiser lawyer, a more acute physician, and a profound astronomer.

It would have been in Italy that Copernicus first learned of the significance of Pythagoras, Philolaus, Ecphantus, Aristarchus and other Greeks who had lived nearly 2000 years before. For these men had been amongst the first to de-mythologise astronomy and discuss what substances the Sun, stars and planets might be made of, what generated and what reflected light, and had even used the total and partial phases of the same eclipse, seen by observers in different places, to make the first estimate of the lunar distance. Geometry, not magic, had been their touchstone to astronomy.

And most important of all, they had seriously considered the possibility that the fiery, life-giving Sun was at the centre of the Universe, rather than the cold, gross Earth. And all of these ideas were very pertinent at a time when the accumulating errors in planetary and calendrical tables were making humanist astronomers ransack the ancients in search of a solution to the problem.

Astronomical research

Nicholas Copernicus, Doctor of Medicine, returned home to Poland in 1503, and never travelled abroad again. He was in so many ways a typical intellectual: of retiring disposition, studious, meticulous and cautious. The ancient Greek medicine which he learned at Padua would have been of no use when it came to combating plague or heart disease, but it would have provided him with a set of concepts and classical clinical models in terms of which to interpret symptoms.

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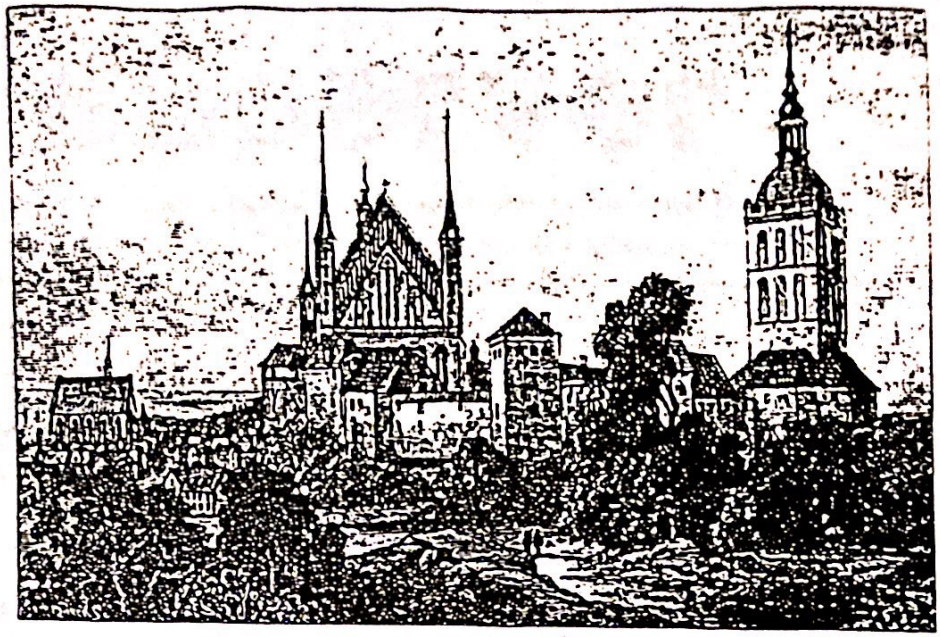
Similarly, the sections of Ptolemy's astronomy which were beginning to be recovered in the pure Greek, rather than reduced from debased Arabic-Latin translations (such as Regiomontanus' influential *Epitome of the Almagest* of 1496), promised a rational solution to the problem of the wandering planets.

Then on March 31, 1513, Copernicus purchased eight hundred building stones for the construction of a tower on which to mount three astronomical instruments: a set of 'Ptolemy's Rulers' (three stout wooden beams hinged together and divided into degrees) to measure the Moon's position; a quadrant to measure the height of the Sun; and an astrolobe with which, in this pre-algebraic age, to compute positions on the stellar sphere. Here, in Fraunburg, he began to test the predicted position of the planets against their actual position, just as Regiomontanus and Walther had done in Nuremburg fifty years before.

What Copernicus had to do to correct the problems of the heavens was to interpret these observations in terms of the elegance and simplicity of pure Greek mathematical theory, and that pre-supposed a reduction in the number of complex epicycles and eccentrics of Arabic and medieval astronomy. And by 1514, moreover, his beloved Greeks, Philolaus, Ecphantus and others had convinced him that their Sun-centred cosmos was actually true. And never a deliberate innovator, Copernicus saw himself as perfecting his admired Ptolemy and giving the credit for his ideas to the Greeks. A copy of his unpublished manuscript *Commentariolus* (1514) is still preserved in Cracow University library.

By putting the Sun at, or very close to, the centre of the Solar System, Copernicus found that he could dispense with five planetary epicycles, and still account for the planets' motions. He also found that by making the Earth move around a fixed Sun, he could explain in a simple, elegant stroke the vexatious retrograde motions of Mars, Jupiter and Saturn. The daily rotations of the stars could also be explained more simply by assuming that just the Earth spun around once every day rather than that the entire firmament did so.

Over the next three decades, Greek humanist astronomy made great progress, culminating in 1538, in the publication of a pure Greek edition of the complete *Almagest*. And yet Copernicus said nothing, until the young Georg Joachim Rheticus won his confidence and persuaded the cautious Canon to finalise the manuscript of his *De Revolutionibus Orbium Coelestium* (*On the Revolutions of the Celestial Spheres*) for press.



Copernicus was Canon of Fraunburg Cathedral. Picture courtesy Dee Levers.

Then in December 1542, Copernicus suffered a massive stroke, and it fell to his disciple Andreas Osiander to see the book through the press. A master of cautious diplomacy to the end, Copernicus received his author's copy on May 24, 1543 only a few hours before he died.

Belated publishing

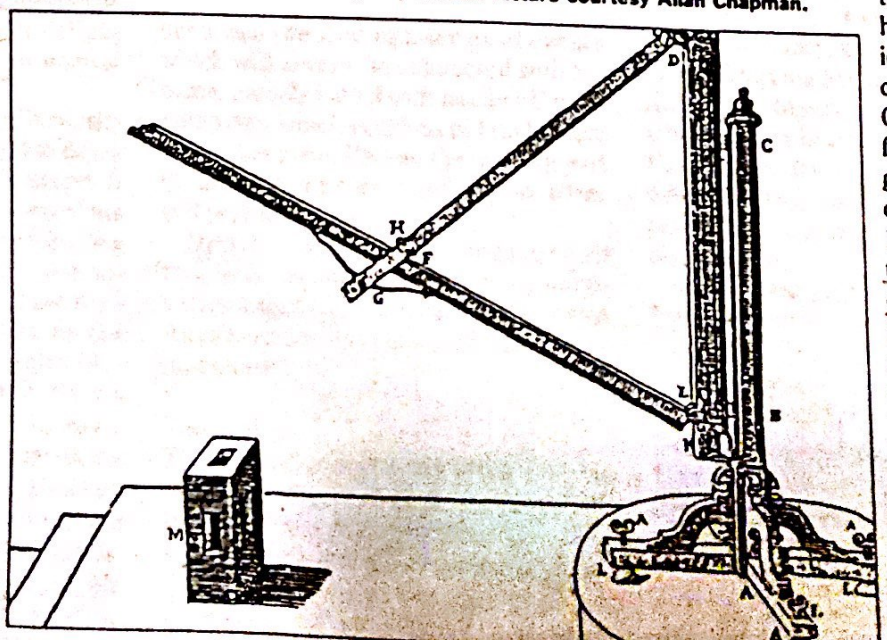
Yet why should Copernicus, if this theory had been there in 1514, wait until 1543 before publishing? Popular tradition assumes that it was because he feared church persecution. Yet in reality, the church had no policies one way or the other about a moving Earth either during, or for long after his lifetime. So, in fact, there were no church laws under which Copernicus could even have been prosecuted; and as a high-level church lawyer himself, he was in an ideal position to know.

The real truth lies in Copernicus' realisation of the seeming common sense absurdity of what he was saying. In the same way that Charles Darwin was to wait from 1839 until 1859 before publishing *The Origin of Species*, so Copernicus delayed for decades until he had built up as watertight a case as the evidence permitted for a theory which he realised, in 1543, lacked clinching proof. It only had arguments from mathematical elegance, but no firm demonstration.

What Copernicus feared was academic ridicule: of being "laughed off the stage" throughout the universities of Europe for putting forth such a preposterous an idea as the Earth whirling through space.

And when the adverse response did come, it was on the grounds of scientific absurdity, and not irreligion. For with the exception of that spectacularly multi-faceted heretic, Giordano Bruno in 1600, not a single Copernican was actually persecuted: and Bruno, in his denial of the Divinity of Christ and the spiritual authority of the Pope, was asserting things alongside which his astronomical opinions paled into insignificance. Indeed, not until Galileo in 1616 were the first anti-Copernican growls uttered by the church, and not until 1633 was the heliocentric theory formally condemned by an increasingly authoritarian church. But by then, the Canon of Faunburg had been sleeping for ninety years.

The Rulers of Parallax were made by Copernicus. Picture courtesy Allan Chapman.



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