

ADELARD OF BATH AND THE ASTROLABE

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No account of the 12th-century renaissance is complete without a reference to Adelard of Bath. He is best known for his translations of scholarly works from Arabic into Latin and for his prominent role in introducing Arab science to Europe. He is often referred to as a Benedictine 'monk', but is more likely to have been a secular member of that order as 'clerk' and then 'master', not one of the enclosed community. As such he would have been free to study and work in almost any court or centre of learning in Europe, provided that he had the permission of his bishop.¹

Although Adelard travelled widely he was proud of his native city of Bath and was generally known as Adelardus or Aethelardus Bathoniensis. His connection with Bath is firmly established by a reference to him in the Pipe Roll of Henry I for 1130 (plate 1²). He is thought by some to have had a minor role in Henry's court,

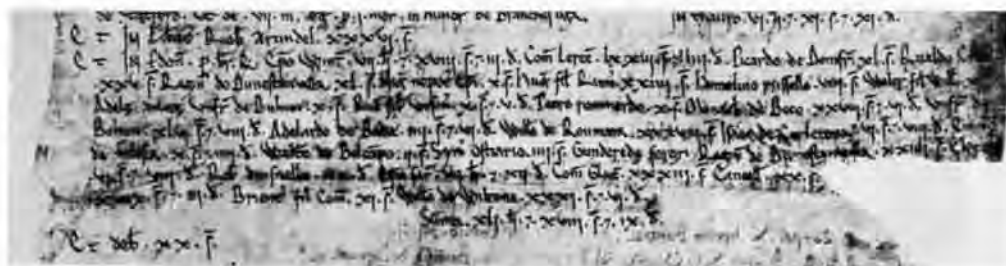


Plate 1

Pipe Roll 31 Henry I (1130): A payment to Adelard of Bath indicates a connection with the court of Henry I.

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perhaps connected with the Exchequer. He himself states in *Quaestiones Naturales* that King Henry had long maintained him abroad for purposes of study.

Adelard was born in Bath shortly before John of Villula became bishop of Wells in 1088³ John moved the seat of the bishopric to Bath, where he was also abbot, and set about reconstructing the city which had been destroyed by fire. He did a great deal for Bath: the King's bath still stands as a reminder of the scale of his activity. He was a physician as well as a Churchman and very interested in the therapeutic quality of Bath's mineral springs. He founded a hospital and a school. He had come from Tours, one of the foremost centres of learning in Europe. The first known fact of Adelard's life is that he went to Tours to complete his education (about 1100). One might well assume that he was a protégé of his bishop.

While at Tours Adelard studied the formal subjects of the Trivium and the Quadrivium, the seven liberal arts which were the foundation of all higher education. He describes these subjects in his early manuscript, *De Eodem et Diverso*. His mathematical talents were already very noticeable at this time. He mentions the astrolabe in the section on astronomy and explains methods of surveying in that on geometry.

His interests extended to the animal world. In his section on music he remarks that amongst the Anglo Saxons fish are known to come to the surface and be netted as the result of playing the cymbals! *De Eodem* reveals Adelard's great seriousness of purpose. He tells how at Tours he had a vision and determined to devote his life to scholarship. The philosophy which he outlines is important in representing the early stages of the movement which developed into Scholasticism. It is Adelard's attempt to reconcile Plato and Aristotle.⁴

From Tours Adelard went to Salerno where those interested in medical studies were congregating. The Norman conquest of Sicily had resulted in many works of Arab scholarship becoming available. Adelard was possibly the first man from the North to study with Constantine the African and was certainly instrumental in spreading the ideas of the Salernitan school.⁵ After Salerno and travels in Greece Adelard taught at Laon, where Henry I's Treasurer sent Adelard's own nephew to be trained for the Exchequer. Another of Adelard's manuscripts gives the rules for using an abacus.⁶ This expertise would have been relevant if he himself were later associated with the Exchequer.

From Laon Adelard set out on a trip to the East deliberately to study Arab science. In several of his manuscripts he used question and answer with his nephew as a literary device. He states in *Quaestiones Naturales* that when he left Laon he arranged with his nephew that he would discuss with him what he had learned from the Arabs on his return. The resulting manuscript became one of the most popular of Adelard's original works, other than his translations.⁷

Adelard does not tell us where or from whom he acquired the information he brought back. We do know from incidental references that he was in Mamistra during an earthquake and that he reached Antioch. It was an extraordinary time for him to be pursuing his studies. The earthquake he mentions is taken to be that in 1114, when the devastation seriously impaired Antioch's defences; more widespread disruption was caused by a number of bloody Crusading battles which took place during the time that Adelard was in the East. Nevertheless he managed to learn Arabic and obviously communicated about mathematics and astronomy with Arab scholars. He re-acquired for the West the thirteen books of Euclid's *Elements*, most of which had been lost in their original Greek,⁸ and a number of Arab works as well.

The texts which Adelard used were ancient. He is best known for his translation of the *Zig* (Ezich) of Al Khwarizmi, but the original *Zig* had been drawn up in the 9th century and Adelard worked from a version revised for use at Cordova. The term 'zig' comes from the Arab 'zij'. It is a collection of astronomical tables which give positions of sun, moon, planets and fixed stars for particular days and years. Adelard converted the Moslem calendar to the Christian thus making the tables available to Western astronomers.⁹

Another text of Al Khwarizmi which Adelard is considered to have translated contains an explanation of Hindu arithmetic and explains the use of zero, as well as giving symbols for digits from 1 to 9. This is why he is given credit for helping to introduce Arabic numerals to Europe.¹⁰ His treatise on the astrolabe, however, uses Roman numerals throughout.

Two further translations introduced aspects of astrology; one was by Abumasha'ar,¹¹ whose works were later the principal astrological authority in Europe, and the other a treatise on horoscopes by Thabit ben Korra.¹²

Virtually all the manuscripts on which Adelard worked as translator appear to have been continuing products of the House of Learning founded by Caliph Mamun in Baghdad two centuries before. It is reasonable to assume, therefore, that copies would be fairly widely dispersed amongst scholars in the Moslem world, although they would not be available through ordinary sources of trade. This is not to underestimate Adelard's achievement. His influence was phenomenal because he understood what he was translating.

After his return from Syria his own writing would have been his main pre-occupation. The translation of the *Zig* is usually dated 1126. After Henry I's death, when civil war broke out between Stephen and Matilda, it is assumed that Adelard

returned to Bath. He was certainly there when he wrote his treatise on the astrolabe.¹³ This can be accurately dated because it is dedicated to Henry Plantagenet (Matilda's son), known to have been with his uncle, Robert of Gloucester, at this time. Henry's tutor was a Master Matthew, but Adelard, living close by, would have been a logical person to call in for lessons on astronomy and mathematics.¹⁴ It is possible that Adelard also wrote his treatise on the care of falcons¹⁵ for Henry, who as Henry II was later very keen on the sport. It is the earliest known manuscript on the subject, but not dedicated to Henry.

The treatise on the astrolabe has had little scholarly attention. It is not the earliest in Europe nor the most detailed — that by Messahalla became the basis of Chaucer's treatise. The more important aspects of planetary theory were dealt with in Adelard's translation of the *Zig* and he states that he will not repeat what he has written there. The *Zig* has raised a number of interesting questions for historians of science because Adelard's translation is now the only available version of Al Khwarizmi's tables. There had been many accretions between the original authorship and Adelard's text. Of particular importance has been the discovery that although there are references to Ptolemy, and Ptolemy's figures for longitude are used with some corrections, much of the material has proved to be non-Ptolemaic.¹⁶

The astrolabe treatise is, however, interesting because of its association with Henry II and because taken in connection with the *Zig* it gives a picture of the basic knowledge of astronomy in England before a complete version of Ptolemy's *Almagest* was available in Latin. It was 1175 before Gerard of Cremona made a translation from the Arabic version found in Spain. He was not aware that a translation was being made in Sicily from a Greek manuscript taken to the court of Roger II. A case has been made out for Adelard's return to Sicily as an old man to assist in the work on the *Almagest*,¹⁷ but by then Adelard would have been in his seventies so it is unlikely. The treatise on the astrolabe was probably his last work.

The McClean MS. in the Fitzwilliam Museum contains a more complete version of Adelard's text than does the Arundel MS. in the the British Library. There are also rough diagrams for two climate plates and a design which relates calendar months and days (specified in Latin not Arabic) to the signs of the zodiac and lists the fixed stars which would be included as pointers on a rete. The McClean MS. includes the dedication to Henry and an introduction on the principles of astronomy.

As an instrument, the astrolabe was known in Europe before Adelard's journey and was later used universally for astronomical observation, navigation and surveying. The Arabs used it for finding Mecca. It was also useful for casting horoscopes as it could be set to show the position of the fixed stars at the hour of a person's birth. Then, by consulting a *zig*, the positions of the planets could be recorded in relation to this. Adelard tells Henry in his introduction that men born to high position should be aware of the 'house in which they are born'. He adds that the purpose of his treatise is to give Henry the knowledge not only of Latin texts but of what the Arabs have to teach concerning the movements of the spheres and the orbits of the stars.

In the introduction¹⁸ Adelard describes the concept of universe basic to the study of astronomy. The universe is spherical and various circles, projected onto a plane from the sphere, can be used for astronomical observations. He explains the ecliptic and the signs of the zodiac and that in considering the course of the sun one must take into account the obliquity noticed by Ptolemy to be a little over 23 degrees.

He describes the instrument itself at the point where the Arundel version of the manuscript begins.¹⁹ It is a circular disc which one suspends from one's thumb, using the pointer on one side to take altitudes and locating the position of stars by revolving the circle of the rete above the climate plate on the other side. The climate plate gives the information required for a particular degree of latitude.

Adelard handles problems of latitude and longitude by using his native city of Bath as the example. He gives Bath's latitude as 52°, which is reasonably accurate. He explains how this is obtained by using the astrolabe, taking the altitude of the sun at noon at the time of the equinox and subtracting the figure from 90°. Alternatively the altitude of the North pole is found by using a star that never sets. (The

standard rule of thumb for finding latitude is to calculate the altitude of the North star.)²⁰

Adelard's measurement of longitude is, however, incorrect by 33 degrees. He gives it as 45 degrees West of Arin,²¹ which is on the site of modern Ujjain in India. Bath is in fact 78° West of Ujjain. How could Adelard make such a colossal error?

To understand what is involved one must know what is meant by Arin — Adelard explains this in the commentary on the Zig. It was theoretically a point on the equator 90° from the North and South poles and 90° from the Eastern and Western extents of the known world. Measurement from Arin had been a Hindu concept, subsequently used by Ptolemy and handed on by Adelard to survive until the time of Columbus.²² The measurements originally were intended to be taken from a great circle which extended from Lanka on the equator, through Ujjain to the North pole. It was a sort of Greenwich meridian. A zig then provided astronomical tables for what could be seen from Arin and if the position East or West of Arin was known by a certain number of degrees a local observation could be related to the information in a zig. According to Adelard since Bath was 45 degrees from Arin an event would be seen there three hours after it had been seen at Arin.

Adelard's error can only be explained by the great difficulty there was in determining longitude until the invention of the chronometer. Ptolemy was 20° out in his estimate of the length of the Mediterranean. Al Khwarizmi corrected 10° of this. Then Arin was considered to be only 10° from Baghdad. This makes Adelard's miscalculation easier to understand. The principle is perfectly correct.

In addition to the astronomical information in the treatise there are explanations of the use of the astrolabe for surveying and for casting horoscopes. Thumbnail sketches illustrate some of the points and are incorporated in the text. The more detailed diagrams in the McClean MS. are here reproduced. The first of these (McClean f. 87) appears to be a climate plate for 48° and as such would be useful to Henry in Northern France. The second climate plate is for 52°, the latitude Adelard ascribes to Bath. The plates are not as precise as those engraved properly on brass, but are adequate to show stereographic projection, the principle on which planispheric astrolabes are based.²⁴

Adelard was quite apparently a man with a tremendous variety of interests and this makes the study of his manuscripts very enjoyable. Tucked in amongst chemical formulae are to be found instructions on how to use a battering ram and how to make boiled sweets from sugar cane.²⁵ In his advice on the care of falcons he urges the handler not to associate with prostitutes lest he infect his bird with vermin.

Since the ninth centenary of Adelard's birth will occur in this decade, it is gratifying that scholarly interest in the more serious aspects of Adelard's work still continues. Bath can be justly proud that the city is always associated with his name.

1 D. Knowles, *Evolution of Medieval Thought* (London 1962), 80, 82, 132.

2 *Pipe Roll*, 31 *Henry I*, ed. J. Hunter (Pipe Roll Soc. 1929), 22.

3 W. Hunt, 'John De Villula', art. in *Dictionary of National Biography*.

4 Adelard of Bath, *De Eodem et Diverso*, ed. H. Willner in 'Des Adelard von Bath Traktat', *Beiträge zur Geschichte der Philosophie des Mittelalters* IV, no. 1 (Munster 1903); G. Sarton, *Introduction to the History of Science* II, pt. 1 (Baltimore 1931), 168.

5 M. Muller, 'Die Quaestiones Naturales des Adelardus von Bath', *Beiträge zur Geschichte der Philosophie und Theologie des Mittelalters*, Band xxxi, Heft 2 (Munster 1934), 90.

6 Adelard of Bath, *Regule Abaci*, ed. Boncompagni, *Bulletino de Bibliografia e di Storia delle Scienze Matematiche* XIV.

7 Adelard of Bath, *Quaestiones Naturales*, ed. H. Gollancz, in *Dodi ve Nechdi* (Oxford 1920); see also Muller, loc. cit.

8 M. Clagett, 'The Medieval Latin Translations from the Arabic of the Elements of Euclid, with Special Emphasis on the Versions of Adelard of Bath', *Isis* 44 (1953), 16-42.

9 Adelard of Bath, 'incipit Ezich Elkaurezmi per Athelardem Bathoniensem ex arabico sumptus' (Tables of Mohammed Ibn Musa al Khwarizmi), *Konelige Danske Videnskabernes Selskab* 4, no. 2, ed. O. Neugebauer (Copenhagen 1962), esp. 23-45. For an earlier edition, ed. H. Suter (Copenhagen 1914).

10 Adelard of Bath (?), Translation of Al Khwarizmi, ed. Boncompagni, 'Algorismi de Numero Indorum', *Trattato d'Aritmetica* (Rome 1857); Cambridge University Library, MS LI, vi, 5 f. 102, attributed to Adelard by Vogel and Youschkevitch. See M. Clagett, *Dictionary of Scientific Biography*.

- 11 R. Lemay, *Abumashaar and Latin Aristotelianism in the 12th Century* (Beirut 1962).
- 12 L. Thorndike, *A History of Magic and Experimental Science* (New York 1923) I. 664.
- 13 Adelard of Bath, 'Incipit Libellus Magistri Alardi bathoniensis de opera astrolapsus', Cambridge, Fitzwilliam Museum, McClean MS 165, ff. 81-88; 'Erit igitur ut astrolabium de mag. Adelard', British Library, Arundel MS 377, ff. 69-74.
- 14 C. H. Haskins, *Studies in the History of Medieval Science* (2nd ed. New York 1960), 24, 30-31.
- 15 Adelard of Bath, *De Cura Accipitrum* (The Care of Falcons), ed. A.E.H. Swaen (University of Amsterdam 1937).
- 16 E. S. Kennedy, 'A Survey of Islamic Astronomical Tables', *Transactions of the American Philosophical Society*, new series 46 (Philadelphia 1956), pt. w, 14, 128, 148, 173.
- 17 F. Bliemetzrieder, *Blätter aus dem Leben eines englischen Naturphilosophen, Adelard Von Bath* (Munich 1935).
- 18 McClean MS 165, ff. 81, 81v.
- 19 Ibid. f. 83; Arundel MS 377, f. 69.
- 20 McClean MS 165, ff. 82v, 84v.
- 21 Ibid. f. 85.
- 22 D. M. Dunlop, *Arab Civilization to A.D. 1500* (London 1971), 154-7.
- 23 J. K. Wright, *Geographical Lore at the Time of the Crusades* (New York 1965), 95; idem, 'Notes on the Knowledge of Latitudes and Longitudes in the Middle Ages', *Isis* V, pt. 1 (Brussels 1923), 75-98.
- 24 G. Chaucer, *Treatise on the Astrolabe*, ed. W. W. Skeat (Early English Text Society XVI, 1872); J. D. North, 'The Astrolabe', *Scientific American* 230, no. 1 (January 1974), 96-106; R. Thomson, 'Jordanus de Nemore and the Mathematics of Astrolabes', *Pontifical Institute of Medieval Studies*, 39 (Toronto 1978); D. W. Waters, *The Planispheric Astrolabe* (National Maritime Museum, Greenwich 1976).
- 25 Adelard of Bath, *Mappe Clavicula*, A Treatise on the Treatment of Pigments in the Middle Ages (subsequently identified as that written by Adelard in a 13th-century MS, British Library, Royal and Kings, 15C 1V), ed. Sir T. Phillipps, *Archaeologia* 32 (1847), 183-244, esp. 237-8, 241.

PLATES 2-6

Reproduced by permission of the Director of the Fitzwilliam Museum, Cambridge, from McClean MS. 165.

2 Folio 86v: Final page of Adelard's text deals with use of astrolabe for casting horoscopes and ends 'Non Penitebit'. He tells his reader, 'You will not be sorry if you learn to use the astrolabe.'

3 Folio 87: First diagram of climate plate, Latitude 48°.

Outer circle is Tropic of Capricorn. Middle circle is Equator (called circle of Aries and Libra). Central circle is Tropic of Cancer. Meridian due South is M (Northern side N). Circular measurements of altitude to Zenith are Almucanters 5° apart. Azimuth arc is from Orientalis Linea to Occidentalis Linea through Zenith. Table gives degrees of declination of stars from equinoctial circle.

4 Folio 87v: Back of astrolabe (incomplete).

This diagram lacks alidade and shadow squares. Shows calendar months, named in Latin, according to appropriate signs of the zodiac for each day. Cancer 1° is on the meridian for the middle of June

Folio 88: Climate Plate for Bath, Latitude 52°.

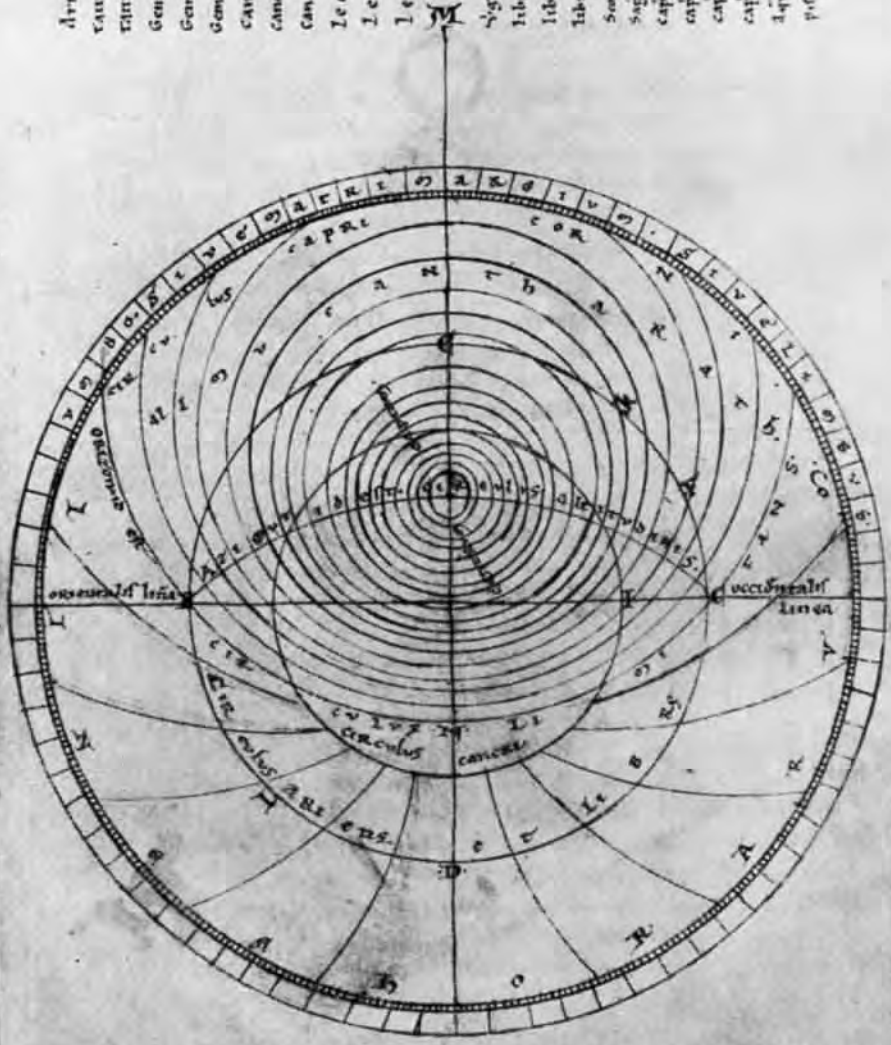
M. Meridian, due South; A. North pole; N. North side of Meridian; B. East on line of Equinoctial colure, intersecting horizon; BC. Arc of azimuth through Zenith; I. Intersection with Tropic of Cancer; h. Intersection with Tropic of Capricorn; L. & K. Points used for calculating almucanters; F. & G., Points on Equator representing 23° North and South Almucanters are 6° apart.

6 Folio 88v: Incomplete design for a rete—star pointers are lacking. Ptolemy's table of fixed stars would provide information for completing the design.

87

numerus graduum declinationis stellarum astrolabice ab equinoctiali circulo septentrionem vel meridiem.

Arctus	xviii
tau	xxv
tau	xvi
Gemma alba	xli
Gemma rubra	xli
Gemma	vii
Cancer	xviii
Cancer	vii
Cancer	xxv
Leo	ii
Leo	xviii
Leo	xli
Sigra	x
libra	xvii
libra	xli
libra	xxi
Serpens	xxv
Sigra	xli
capra	xxvii
capra	xxi
capra	xli
capra	xxv
capra	xxi
capra	xli
capra	xxv
capra	xxi



88

