The progress of astronomy in England – Earliest times to 1558

A. J. Kinder

The history of astronomy in England up to the start of the reign of Queen Elizabeth I is outlined. Secondary sources have been used and the article highlights the most important names and events as they occur. The termination date of 1558 was chosen becaue it is the dividing line between the old and new astronomy in England. During this period, astrology was considered to be on an equal footing with astronomy, and therefore as important. Many of the astronomers of this period were astrologers and *vice versa*. A bibliography gives the major sources used.

Introductory historical note

The purpose of this article is to outline the development of astronomy in England. The political development of the area now known as England is not straightforward. In Celtic and Roman times, England did not exist, being known as Albion or Britannia to the classical writers. The arrival of the Angles, Saxons and Jutes from the fifth century was the source of the name England. Even then, and until the tenth century, the political boundaries were not fixed. Areas of lowland Scotland were at one time a part of the Anglo-Saxon kingdom of Northumbria, whilst Cornwall and Devon remained as a separate kingdom, called Dumnonia, until the mid-tenth century. The border with Wales was not finally fixed until after the Norman Conquest.

Figure 1. Map showing locations of places in England mentioned in the article; and the maximum boundary of the Anglo-Saxon kingdom of Northumbria.

For the purpose of this article, 'Britain' refers to the period up to the end of the Roman occupation, while England refers to the period following it. In all cases, the area covered is within the present day political boundaries.

The beginning

For this period, and for much of the later ones, we have the same problem as other historians, namely the lack of primary, accurate, source material. Consequentially, no claim to originality is made. Depending on individual beliefs, the standing stones and circles which proliferate in Britain may have astronomical application. The most famous of these being, of course, Stonehenge (Fig. 2), built *c.* 3100–1500 BC. At this time, Britain was inhabited by Neolithic man, whose culture has all but vanished. If it followed the same pattern as the other pagan cultures, it would have had a primitive cosmology. The association of these artifacts, in particular Stonehenge, with the Celts is apocryphal, as the various Celtic tribes did not arrive in Britain until the seventh century BC onwards.

Celtic and Roman Britain

The arrival of the Celts in Britain is deduced from archaeological excavations. Their culture included astronomy, which is indicated by references made by Greek and Roman authors (e.g. Strabo, Caesar). In particular, specific mention must be made of their astronomical and calendrical computations. Due to the non-existence of written records, this knowledge is now largely lost, although not completely. The astronomers of this culture, as with all primitive ones, would have been members of the priesthood, which in the case of the Celts were of the Druidic Caste.

The Roman invasion of Britain and its subsequent occupation does not seem to have had any impact with respect to astronomy. In fact, the Romans themselves had no real indigenous astronomical culture or tradition. They preferred to use the Greek discoveries and writings, and to adapt them to their own practical

Figure 2. Stonehenge (courtesy of E. Watson Jones).

Figure 3. Astronomical Mosaic at Brading Villa (courtesy of Mr N. Dogliani and Mr S. Dunlop).

outlook. Philosophical speculation for its own sake was virtually unknown, as any knowledge had to be seen to be of use. This does not mean that there were no astronomers at all, but they were mainly commentators on early works, or compiled 'encyclopaedias' of all known knowledge of the natural world. Amongst these can be included Julius Caesar (102–44 BC), the first Roman invader of Britain (55 BC and 54 BC), who is said to have written a book on astronomy (now lost) and was responsible for the reform of the calendar.

In so far as Britain is concerned, the only visible sign now extant of any interest in astronomy in Roman Britain is on the Isle of Wight, at Brading, where a Roman villa, excavated during the 19th century, and more recently, is preserved. Part of the surviving building includes a mosaic of about the 3rd or 4th century AD. This mosaic includes a figure of what may be an astronomer (suggested to be Anaximander *c.* 610– 545 BC). This figure can be seen pointing to a globe resting on a stool at his feet, while at his right hand is a sundial supported by a pillar. On his left is some kind of planisphere or gnomon. There is evidence recently uncovered that, in part at least, this was restored by the Victorians. Only one other similar mosaic is known, in Trier, the Federal Republic of Germany. Its function is highly speculative, but probably of a decorative nature (Fig. 3). During the four centuries of Roman occupation it is not unlikely that astronomy was pursued as an intellectual interest or hobby.

Civil disturbance of any form is not conducive to academic pursuits in any age, and the 250 years or so following the Roman withdrawal from Britain (*c.* 410–650) were to be no exception.

Often, but inaccurately, called the 'Dark Ages', this period was one of invasion and counterinvasion, of anarchy and chaos. Consequently, it would be fairly safe to assume that astronomy, like all other peaceful pursuits, was not actively followed. By the mid-seventh century, virtually the whole of what is now modern England was occupied by the Anglo-Saxon invaders.

Anglo-Saxon England

In 597, under the instruction of Pope Gregory I (*c.* 540–604, Pope from 590), a mission, under the leadership of Augustine (*d.* 604/5) arrived on the coast of Kent to undertake the conversion of the pagan English to Christianity. (N.B. Christianity had arrived in Britain during the Roman occupation but, with the invasion of the pagan Angles, Saxons and Jutes, the Christian Britons were gradually driven westward to what is now Wales and South-west England.)

Although the king of Kent, Ethelbert I (*d.* 616), was a pagan, his wife was not, and so the mission was allowed to stay and begin its work. Augustine became the first Archbishop of Canterbury, after establishing the See there.

Some fifty years later, a successor, Theodorus of Tarsus (Greek, *c.* 602–690) established a school at Canterbury, whose curriculum included astronomy. This would be the first known instance of astronomy being taught in England. It should be pointed out that during the whole of the Anglo-Saxon period, and into the Norman period, knowledge of astronomical science, in particular its sub-branch 'Computus', was essential for the calculation of the Church's feast days and festivals (especially Easter). Computus was that part of astronomy which dealt with these calculations, and dominated astronomical thought, especially in the Church. Therefore, astronomical research for its own sake was very limited. The astronomy of this period was the astronomy of Pliny the Elder (23–79), and of the encyclopaedist Isidore of Seville (*c.* 570–*c.* 636); the astronomy of Ptolemy was virtually unknown due to the loss of contact with the east, especially after the rise of Islam from the seventh century.

During the seventh century, many Irish scholars, untouched by civil strife, came to England, bringing their knowledge of astronomy with them. (After the Roman withdrawal from Britain and most of Europe, and the consequent barbarian invasions, Ireland was virtually the only place where Latin culture and knowledge remained intact in its purest form.)

The influence of these scholars led to the phenomenon of what later was to be called the 'Northumbrian Renaissance'.

Why Northumbria and not another Anglo-Saxon kingdom was to achieve this distinction is still subject to debate, but until the Viking invasions of the later eighth and ninth centuries this was so.

The most famous figure of this period is the Venerable Bede (*c.* 675–735), who entered the monastery of Monkwearmouth at the age of 7, and was to become the greatest scholar of his time. He is better known for his *Ecclesiastical History of the English Peoples* (731); but he wrote on nature and science. For astronomers, his two most important works are the *De Temporibus*, which, with its sequel *De Temporibus Ratione* (701/702), dealt with the problem of calendrical and canonical reckoning, while the second work, the *De Natura Rerum* (*c.* 701) dealt with the world about him, including the celestial bodies. His scientific writings and teachings reflect the beliefs commonly held then of the natural world. He incorporates Anglo-Saxon star lore, and spoke of comets and meteors as the harbingers of the judgement of God. He believed that the Earth was the centre of the universe, and created by God, as were the Sun, Moon and stars. The Earth was a globe, and he supported this statement by using the apparent motions of the Sun and stars as proof. Two other achievements of his are worth mentioning – the correct description of the effect of the Moon on the tides, and the practice of dating events from the birth of Christ (first suggested by Dionysius Exiguus, *fl.* 500–550.)

Bede was the most prominent of Anglo-Saxon scholars intersted in astronomy, but there were others who, like him, were also in clerical orders.

Amongst these can be included Aldhelm of Malmesbury (*c.* 640–709), a product of the Irish schools and a pupil of Theodosus of Tarsus, who is better known for being the possible author of many riddles, including some on the Sun, Moon, stars and the Earth. He also calculated the date of Easter using astronomical and arithmetical means. Alcuin of York (735–804) was responsible for taking the Anglo-Irish learning to the continent, the court of Charlemagne in 782. This was to serve as the basis of a revival of European learning. He is said to have made astronomical calculations to determine the date of Easter. St Athelwold (*c.* 908–984, bishop of Winchester from 983), is said to have written a treatise on the circle (Bodleian, Digby Ms 893 fol 84), which included illustrations of some of the constellations, and of diagrams explaining the causes of eclipses. Aelfric the Grammarian (*fl.* 990), better known as the author of sermons and other ecclesiastical works, was the author of a computus *De Temporibus Anni* (before 1011), which was a short treatise in Old English on chronology, astronomy and natural phenomena, and was a major source for Byrhtferth.

Towards the end of this period, two others of importance appeared. The first, Byrhtferth (*fl.* 1000–1015), wrote what was probably the last Anglo-Saxon astronomical work of major interest, now known as *Byrhtferth's Manual* (1011). Again this was mainly a computus, and was heavily influenced by the works of Bede and Aelfric. He was a monk of Thorney Abbey, later moving to Ramsey Abbey, where he taught astronomy and the principles of mathematics. He was a pupil of Abbo, the future abbot of Fleury, (*c.* 945–1004) who taught astronomy and mathematics at Ramsey in the mid 980s. The second was Oliver of Malmesbury (*d. post* 1066), a monk at Malmesbury Abbey who is better remembered for his failed attempt to fly (breaking both his legs in the process). He also observed the comet of 1066, April, and saw in it a sign of disaster for England (as occurred at Hastings); his astronomical writings are now presumed lost.

Before moving to the post-Conquest period, mention must be made of what is without doubt the greatest vernacular record of any country – the *Anglo-Saxon Chronicle*. Originally written during the reign of Alfred

the Great (848–899, king of the West Saxons 871–899), it developed as a (albeit biased) record of the events of successive years, until *c.* 1154. In its pages mention is frequently made of many astronomical events – comets, meteors, aurorae – whilst the latter part, written during the eleventh and twelfth centuries, was written by a monk with strong astronomical (or more probably astrological) interests.

The Norman period

During the eleventh century, and especially during the reign of Edward the Confessor (*c.* 1003–1066, king from 1042), many scholars from Lotharingia were encouraged to come to England. (Lotharingia covered what is now north France, Belgium, and part of Germany.) Upon arrival they were placed into positions of authority in the church. They were particularly interested in astronomy and mathematics, either for its own sake, or for reasons to help with the running of the church festivals or the keeping of the financial accounts.

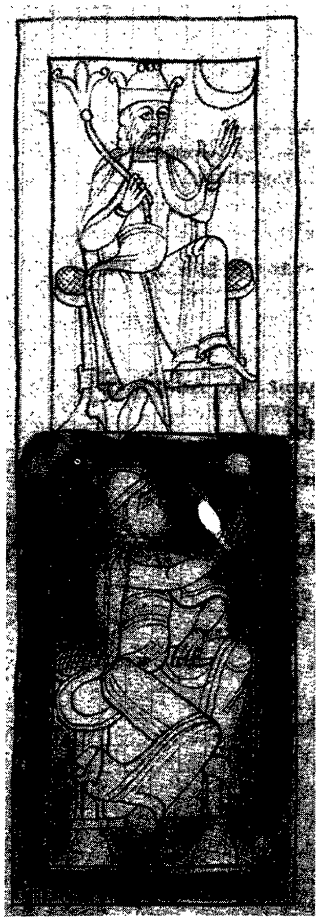


Figure 4. Twelfth century astronomers lecturing (top) and measuring the apparent diameter of the Sun (bottom) (copyright, Bodleian Library).

Of these, the most interesting was Walcher of Malvern (*d.* 1125) who was Prior of Malvern Abbey, and originally came from Lotharingia. Despite his origins, he is frequently described as the first English astronomer. In 1091 he was in Italy, during which time he observed a lunar eclipse. When he returned to England he compared his results with those of a colleague and determined the time difference between the two countries. The following year he observed a lunar eclipse in England and, in doing so, was the first person known to have used an astrolabe in Western Europe.

A possible major influence on Walcher was Petrus Alfonsus (*c.* 1062–1115) a Spanish Jew who became a Christian about 1109, and to escape the unwelcome attentions of the Spanish Jews came to England in 1110 as the personal physician to king Henry I (1068–1135, king 1100–1135). It would seem that, as well as being Alfonso's first pupil, Walcher learnt about Arabic astronomy from him.

Of other known astronomers of this period almost all were of Lotharingian origin. Robert of Losinga (*d.* 1095, bishop of Hereford 1079–1095) had a reputation of being an astronomer of some skill and wrote on the subject. Honorus Inclusus (*fl.* 1090), a Benedictine monk, also wrote on astronomy and the work *Imago Mundi* may be his.

The Twelfth Century Renaissance

To the historian of science, the twelfth century is one of scientific rediscovery. Because of the effects of the cultural contacts between the Latin west and of the Islamic/Byzantine east (one of the better results of the First Crusade, 1096, and the Norman occupation of Sicily from 1072) the science of Classical Greece, lost to the west, but preserved by the east, became available again to Latin Europe.

Due to the similar political structure, Englishmen were attracted to Sicily to find employment in the Sicilian court. Consequently, English scholars were to play a leading role in the transmission of Arabic/Greek science to the west. Unfortunately, the names of many of these are unknown, while others would have the same or similar names, (e.g. there were several John the Englishmen or John of England), and one or more may well have studied astronomy.

Of this period, the four leading names may be considered – Adelard of Bath, Daniel of Morley, Roger of Hereford and Robert of Chester.

Adelard of Bath (*c.* 1080–1155) was a contemporary of Walcher of Malvern. Adelard studied and travelled in France, and was to become the tutor of the future Henry II of England (1133–1189, king 1154–1189) later in his life. His chief claim to fame is as a translator of Arabic science into Latin. His translation of Euclid's *Elements* was to be the standard geometry textbook for centuries. Amongst his astronomical translations were the tables compiled by al-Khwarizimi (*c.* 780–*c.* 850)

and his treatise *Quaestiones Naturalis* is based on Arabic science. He also wrote a treatise on the astrolabe and on the abacus.

The next three are all near contemporaries: Daniel of Morley (*d. c.* 1210) Roger of Hereford (*fl.* 1170) and Robert of Chester (*fl.* 1170.) Robert of Chester was also a leading translator and scientific innovator of his time, revising Adelard's version of the tables of al-Khwarizmi as well as compiling his own. He also made the first Latin translation of the Koran. Daniel of Morley is said to have studied at Oxford, Paris and Toledo. Upon returning to England after his studies he chose to live at Hereford, as he felt that academically it was better than Oxford. His astronomical work included the adaptation of the Toledan tables for the latitude of Hereford, while another treatise deals with the properties of planets in various countries. Roger of Hereford was author of several treatises, including a *Theorica Planetarum*, describing Hindu procedure for determining planetary latitudes. Of this period there exists a manuscript which depicts (possibly) English astronomers making observations, one of the sun using calipers to measure its apparent diameter (Fig. 4), a second making altitude measurements of a star using an astrolabe (Fig. 5) and a third of a figure sitting, presumably lecturing (Fig. 4) (Bodleian MS 614 fols 2r and 35v).

The Thirteenth Century

For the thirteenth century, only three names need be considered – John of Holywood (Johannes Sacrobosco *c.* 1160– *c.* 1256), Robert Grosseteste (*c.* 1170– 1253, bishop of Lincoln 1235–1253) and Roger Bacon (*c.* 1219–1292.)

Sacrobosco was the author of what was to become the most influential textbook for the next four centuries. The *De Sphaera* was one of the principal books which led to the ascendancy of the Ptolemaic system over the Aristotelian one. The place and dates of his birth and death, as is even his country of origin, are not known for certain. The generally accepted view is that he was of English birth, yet lived and was educated in France.

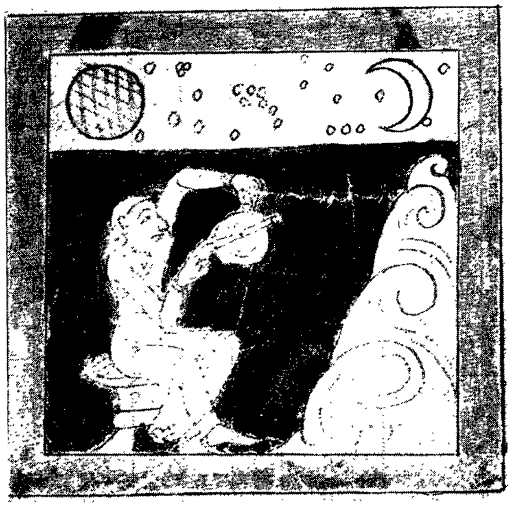


Figure 5. Twelfth century astronomer measuring altitude of a star using an astrolabe (copyright, Bodleian Library).

In contrast, Robert Grosseteste is much better known. He was born of humble parents in Suffolk, possibly educated at Lincoln and then at Oxford. He entered the employ of William de Vere, bishop of Lincoln by 1198 and by 1215 he was lecturer in theology in Oxford. Later in life he was said to have been able to read and understand Greek, a rare accomplishment for this period. During the next two decades he became a leading figure at the University of Oxford, becoming its first Chancellor (1225–1230). Soon after the establishment of the Franciscan Order in England, he was the first lecturer in theology to the order. He finally became bishop of Lincoln in 1235; his reputation was that of a stern and rigid churchman who feared neither king nor pope.

As a scientist, he was to play a leading role in the establishment of the scientific tradition at Oxford, which was to become the leading centre for natural science in Europe over the next century.

For our purposes we can consider his work in astronomy and optics. In astronomy he wrote on comets (*De Cometis*); a *Computus* which underwent several revisions by Grosseteste; a short work on the cosmological implication of light in the Universe (*De Luce*); a *De Sphaera* which may be contemporary to that of Sacrobosco's; and on the scintillation of stars, which he believed to be the effect of strain on the eye, rather than a phenomenon of the stars. He also wrote on calendar reform (*Canon in kalendarium*) and on astrological influences (*De impressionibus aeris seu de prognosticatione*). In his *De Sphaera*, and in his *De motu supercaelestium* he wrote on Aristotleian and Ptolemaic theoretical astronomy.

In optics his use of the logical, mathematical principle which he advocated can be clearly seen, when explaining the properties of mirrors, lenses and the rainbow. According to Crombie, he was the first medieval writer to discuss these subjects systematically. His most important treatise in optics was the *De iride seu de iride et speculo*, which dealt with perspective, magnification and refraction. Throughout his works, if not always clearly, he advocates the principle of experiment and deduction by experience, which was the antithesis of Aristotelian practices in vogue in Europe at this time. No dates have been given for his works as they are still subject to some controversy.

Grosseteste's successor in the natural sciences was Roger Bacon. Bacon wrote and commented extensively on many areas of natural science, in particular the fields of optics and calendar reform – following in the footsteps of Grosseteste. According to some authorities he made references to what amounts to a description of the optical principles of the telescope. His major works

were the *Opus maius, Opus minus* and *Opus tertium*, which contains his writings on astronomy and optics amongst other subjects.

Richard of Wallingford (*c.* 1292–1336), abbot of St Albans Abbey, studied at Oxford, and is better known for his astronomical clock – the Albion – and also wrote extensively on astronomical subjects.

Mention can be made briefly of others interested in astronomy at this time, while space does not allow further exposition – Matthew Paris (*c.* 1200–1259), who incorporated astronomical items in his works, including diagrams of solar and lunar eclipses, the solar system and the Moon; John of London (13th century); Roger Middleton (*d.* 1307); John Pecham (*c.* 1230–1292, Archbishop of Canterbury from 1279); William the Englishman (*fl.* 1220–1230), who resided in Marseille; and Walter of Odington (*fl.* 1280–1330.)

The Merton School of Astronomy

During the fourteenth century, Oxford, and in particular Merton College, was to become the centre of natural science in western Europe, especially in the field of astronomy and mechanics. Why it should have been Merton College in particular is still subject to conjecture, unless it is because most of those interested in natural science were Fellows of Merton College, but this must be treated with a great deal of caution.

During this period in Europe, two schools of thought were developing; they can be represented respectively by Oxford (that the basis of knowledge of natural science was one of experimentation and observation using mathematical principles, in the style of Grosseteste and Bacon) and Paris (where the authority of Aristotle and others were to be accepted without question).

The founder of the Merton College group is said to have been John Ashendon, or Eastwood (*fl.* 1340), and whose surname has over a dozen variants. With William Rede (*c.* 1325–1385), he is said to have foretold the Black Death (1349) from a lunar eclipse. Ashendon and Rede worked together in astronomy. Rede was a founder of Merton College Library, leaving several books and manuscripts to it in his will, as well as to Exeter College. Some of these are now in the Bodleian library.

Other, more shadowy, figures include Reginald Lambourne (*fl.* 1363), a monk of Eynsham, who wrote a letter on astronomical subjects to John of London (*fl.* 1363), dealing with an eclipse in 1363; Nicholas of Lynn (*fl.* 1386) was a lecturer in theology in Oxford and compiled a calendar for the latitude and longitude for that city for 1386–1462 (a period covering four metonic cycles); John Somer, a Franciscan friar (*fl.* 1383), who on the instruction of the provincial head of his order, wrote a calendar which included astronomical tables for the then Princess of Wales – Joan – mother of Richard II.

The group continued into the fifteenth century, but was of a lower standard. The astronomical work carried out was less exact. The names of some of the astronomers are known, but little else. Many of the books and manuscripts of this period were destroyed during the Protestant reformation in the mid-sixteenth century due to the (unfounded) fears that they were Popish tracts and therefore the works of the Devil.

Although Merton was the centre, astronomy was pursued elsewhere. At New College, for example, provision for two students to study astronomy at an advanced level (for master's degrees) were made. This was an unusual provision as astronomy was not a separate faculty, generally being included in the course of study laid down by the Faculty of Arts. This provision was eventually merged with the Savilian Professorship of Astronomy in the nineteenth century, with the costs being borne by New College. Consequentially, the holder of this office is the direct lineal descendant of the medieval astronomers.

The only astronomer to have held a studentship before the sixteenth century and who is known by name is John Walter (*d. c.* 1412), who compiled astronomical tables and wrote on astronomical subjects. Two other philosophers of about this time must be briefly mentioned – Roger (*d. c.* 1365) and Richard (*fl.* 1340) Swineshead – both of whom wrote on astronomical subjects, but because of the similarity of names and dates, they are often confused with each other.

In contrast to its present status, Cambridge played a small role in the development of astronomical research during this period. But despite this, some Cambridge scholars were important, the most prominent being John Holbrooke (*d.* 1437), who was spoken of as a leading astronomer. According to Lewis of Caerleon, he was without equal in England for speculative astronomy and is said to have compiled astronomical tables.

Geoffrey Chaucer (*c.* 1340–1400) is better known as the author of the work *The Canterbury Tales*, but he also wrote the *Treatise of the Astrolabe* and probably, but still subject to some debate, the *Equatorie of the Planetis*.

Early Tudor England

The early Tudor period, like many dynasties during the late medieval/early modern period, arose out of social upheaval and change. As already mentioned, war is not conducive to academic scientific research; in this event, however, the two overlap.

Lewis of Caerleon (*d. c.* 1494) and Henry de Clifford (1455–1523) were two persons caught up in the internecine conflict known as the Wars of the Roses (1455–1485). Lewis was imprisoned in the Tower of London by Richard III (1452–1485, king from 1483) because of his Lancastrian sympathies. He made use of the tables of the earlier Merton and Cambridge astronomers, and compiled tables himself, which he presented to the two universities, as well as calculating solar and lunar eclipses; he also translated and annotated the astro-

Figure 6. Title page of Recorde's *The Castle of Knowledge* (1556) (copyright, Royal Astronomical Society Library).

nomical tables of Johannes Ligneris (*fl.* 14th century). Henry de Clifford was the heir to the barony of Westmorland and 14th Lord Clifford. He too because of his Lancastrian sympathies was in danger of his life, and was compelled to act as a shepherd during the Yorkist rule. He is also reputed to have had a serious interest in astronomy, and built a tower at his home in Barden, near Bolton, from which he was able to observe the heavens.

Three figures, two of them were near contemporaries need finally to be mentioned.

The first is John Dunstable (*c.* 1390–1453), who is better known as the most celebrated English composer of his time. In later life he was to develop an interest in astronomy and there are two volumes of astronomical treatises associated with him (written later than 1421 and in 1438 respectively). It may have been more towards the end of his life that astronomy took a more dominant role in his life; an epitaph (since destroyed in the Great Fire of 1666) called him 'this new Ptolemy, this younger Atlas supporting the arc of the heavens'.

Leonard Digges (*d.* 1559) came of an old Kentish family and was interested in elementary mathematics as applied to navigation, gunnery, surveying and astronomy. He was possibly one of the last serious astronomer/astrologers (although not the last; for example, John Dee (1527–1608), was one also). His work *A Prognostication of Right Good Effect* (London, 1555), later retitled *A Prognostication Everlasting* (London, 1556), went into eleven editions before 1600. It is basically a collection of rules by which a person could predict the weather for himself. What is more interesting is that it also contains descriptions of astronomical instruments and some miscellaneous astronomical information. There is also a 'Peculiar Kalendar' which is a series of tables for use with a sidereal and lunar dial.

Digges was apparently involved in Wyatt's Rebellion (1554) against Queen Mary I (1516–1558, reigned from 1553), possibly being one of the ringleaders, and in consequence of which he was attainted (i.e. accused of high treason, whereby all titles and property are seized by the crown). This was later reversed by Queen Elizabeth I (1533–1603, reigned from 1558.)

Probably the most important astronomer of this period was Robert Recorde. Born about 1510 in Tenby, Pembrokeshire, of an old Kentish family, he was to graduate from Oxford and became a Fellow of All Souls College in 1531. It would seem that he obtained a licence to practice medicine and received his BM degree sometime about 1533. By 1545 he was in Cambridge receiving his MD there. He practised medicine in London and held various appointments under the crown, for example comptroller of the Bristol Mint and later was to be surveyor of mines and monies in Ireland.

Recorde's interests were profound, covering natural science, medicine, law and Greek studies He was an antiquarian, a collector of manuscripts and one of the first students of Anglo-Saxon. In the natural sciences he is chiefly remembered for his mathematical writings, and is called the founder of English school of mathematical writers.

What makes him stand out is that he wrote in the vernacular, rather than in Latin, the language of scholarship of that time. This enabled a wider readership of scientific works, reaching out to the educated rising middle class. He wrote his books in the order that he meant them to be read – viz. arithmetic, plane geometry, practical geometry, astronomical, theoretical arithmetic and algebra. His work on arithmetic *The Ground of Artes* (1543) was the most popular, while a further work *The Whetstone of Witte* (1557) made the use of the equals (=) sign for the first time in mathematics. His astronomical work *The Castle of Knowledge* (1556) (Fig. 6), was an elementary exposition of Ptolemaic astronomy, using Ptolemy, Proclus, Sacrobosco and Finaeus as his authorities. More so than in his earlier works he made a critical examination of the standard authorities accepted at the time, and significantly for the way the future of astronomy was to develop, he gave a favourable treatment of the new heliocentric system proposed by Copernicus. Further projected works, including one on advanced astronomy, probably never appeared.

Conclusion

The death of Recorde in 1558 coincided with the end of the reign of Queen Mary I. The following reign of Queen Elizabeth I was to see a flowering of English learning in the arts and sciences, which, to a greater or lesser degree, continues to the present day. It was to see a new era in discovery, scientific as well as geographical, and the rise of England as a major force in world politics. It also sees the start of modern astronomy in England, which falls outside the scope of this article but had an heritage to be proud off and a springboard for greater things to come.

Acknowledgements

I would like to thank the following individuals and institutions for their help: the Bodlian Library, University of Oxford; Mr P. Hingley, RAS Librarian; Miss P. Barber, BAA Assistant Secretary; Mr M. Tosdevin, Curator, Isle of Wight Archaeological Centre; Mr E. Watson-Jones; Mr P. Gill; Mr S. Dunlop; and Mr N. Dogliani. In particular I thank Mr C. Ronan whose work *Their Majesties' Astronomers* was the cause of my interest in the history of early English astronomy in the first place.

Address: 16 Atkinson House, Catesby Street, London SE17 1QU.

Bibliography

Dictionary of National Biography

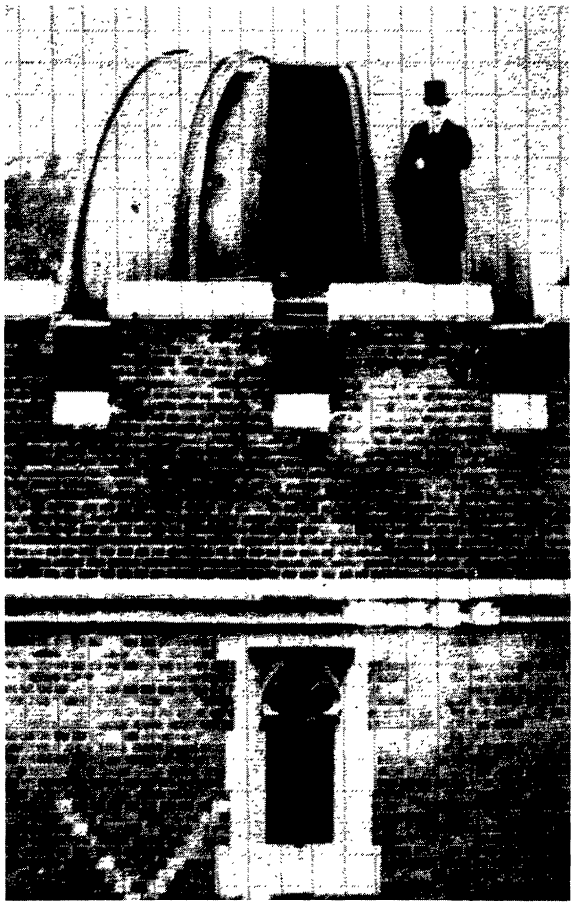
Dictionary of Scientific Biography

Aelfric (ed. H. Henel), *De Temporibus Anni* Oxford 1942
Atkinson, R. J. C., *Stonehenge* London 1956
Blair, P. H., *Northumbria in the Days of Bede* London 1976
Burnett, C. (ed.), *Adelard of Bath* London (Warburg Inst.) 1987
Buxton, J. & Williams, P., *New College Oxford, 1379–1979* Oxford 1979
Byrhtferth (ed. S. J. Crawford), *Manual* Oxford 1966
Callus, D. A. (ed.), *Robert Grosseteste* Oxford 1955
Catto, J. I. (ed), *The Early Oxford Schools* (vol. 1 of The History of the University of Oxford) Oxford 1986
Chaucer, G. (ed. W. W. Skeat), *A Treatise on the Astrolabe* Oxford 1968
Crombie, A. C., *Grosseteste and the Growth of Experimental Science* Oxford 1971
De Morgan, A., *Notices of English Mathematical and Astronomical Writers between the Norman Conquest and the Year 1600* Companion to the The British Almanac for the year 1837
Digges, L., *Prognistication* Old Ashmolean Reprint of 1555 Oxford 1926
Easton, S., *Roger Bacon and his Search for a Universal Science* Oxford 1952
Embden, A. B., *Biographical Register of the University of Cambridge* Cambridge 1963
Embden, A. B., *Biographical Register of the University of Oxford* Oxford 1957–9; in 3 volumes
Feingold, M., *The Mathematician's Apprenticeship* Cambridge 1984
Finberg, H. P. R., *The Formation of England 550–1042* London 1976
French, R. & Greenaway, F., *Science in the Early Roman Empire* London 1986
Garmonsway, G. N. (trans.), *The Anglo Saxon Chronicle* London 1975
Gunther, R. T., *Early Science in Oxford: vol. II Astronomy* Oxford 1923
Hoskins, C. H., *Studies in the History of Medieval Science* New York 1960 (esp. chapter 6)
Hunt, R. W., *English Learning in the Late Twelfth Century* Transactions of the Royal Historical Society 4th series, vol XIX pp.19–35 1936
Johnson, F. R., *Astronomical Thought in Renaissance England* New York 1968
Hoskins, C. H., *The Renaissance of the Twelfth Century* Cambridge, Mass. 1927
Kaplan, E., *Robert Recorde* Ph.D thesis, New York 1960
Leader, D. R., *A History of the University of Cambridge: vol 1. The University to 1546* Cambridge 1988
McLean, A., *Humanism and the Rise of Science in Tudor England* London 1972
Metlitzki, D., *The Matter of Araby in Medieval England* London 1977

Nicholas of Lynn (ed. S. Eisner), *Kalendarium* London 1980
North, J. D., *Chaucer's Universe* Oxford 1988
North, J. D., *Richard of Wallingford* 3 volumes, Oxford 1976
Poole, A. L., *Domesday Book to Magna Carta 1087–1216* Oxford 1955 (vol 3, Oxford History of England 2nd. edition)
Powicke, F. M., *The Medieval Books of Merton College* Oxford 1931
Piggott, S., *The Druids* London 1975
Price, D. J., *The Equatorie of the Planetis* Cambridge 1955
Ronan, C. A., *Their Majesties' Astronomers* London 1967
Russell, J. C., *Hereford and Arabic Science in England about 1175–1200* Isis vol 18 pp 14–25 1932
Sarton, G., *Introduction to the History of Science* New York 1975 3 volumes in 5 parts
Southern, R. W., *Medieval Humanism* Oxford 1970
Southern, R. W., *Robert Grosseteste* Oxford 1986
Stenton, Sir F., *Anglo Saxon England* Oxford 1971 (vol 2, Oxford History of England 3rd. edition)
Stevens, W. M., *Bede's Scientific Achievement* Parish of Jarrow, 1985 Jarrow Lecture
Thompson, J. W. *The Introduction of Arabic Science into Lorraine in the Tenth Century* Isis vol 12 pp 184–193 1929
Vaughan, R. *Matthew Paris* Cambridge 1979
Wellborn, M. C. *Lotharingia as a Center of Arabic and scientific influence in the eleventh century* Isis vol 16 pp 188–199 1931
West, A. F. *Alcuin* New York 1969

Received 1989 March 1; accepted 1989 June 28

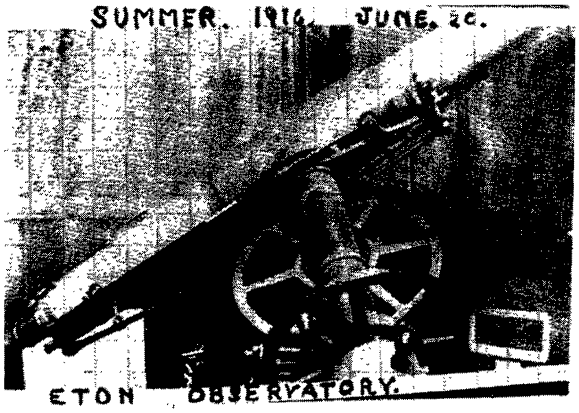
Our longest-standing member remembers – continued from page 181



Exterior view of Eton observatory with Mr. Tiarks beside the dome.

and funds . . . I am also in touch with the Astronomical Society of Gibralter and both visit me occasionally to use my telescope.

Please remember me to your nice secretaries who are always so kind to me when I drop in for a chat."



Interior of the Eton College observatory in the summer of 1916.