In its first five hundred years Oxford University had many fine mathematicians, astronomers and philosophers – from the Merton scholars of the early 14th century to the newly appointed Savilian Professors of Geometry and Astronomy in the 17th century.

UNIVERSITY OF OXFORD

Mathematical Institute

Early mathematics in Oxford

John Killingworth (c.1410–45), the best of the Merton School astronomers, is remembered on a memorial brass in Merton College Chapel.

Time-line

1150–1200	Oxford University comes into being
c.1224	Robert Grosseteste becomes Chancellor of Oxford University
c.1238	Roger Bacon comes to Oxford
1249–64	University, Balliol and Merton Colleges founded
1300–49	The Merton School flourishes
1320s	Richard of Wallingford in Oxford
1349	Black Death: death of Thomas Bradwardine
c.1360	The Merton astrolabe
1391	Chaucer's *Treatise on the Astrolabe*
1520	Oxford's first printed mathematics book, the *Compotus Manualis*
1522	Cuthbert Tunstall's *De Arte Supputandi*
c.1537	Richard Benese's *Boke of Measuryng of Lande*
1543	Robert Recorde's *Grounde of Artes*
1557	Recorde introduces the equals sign
1570	Henry Billingsley's English edition of Euclid's *Elements*
1581	Pelican sundial erected in Corpus Christi College
1585–86	Thomas Harriot's expedition to North America
1613–24	Schools Quadrangle built
1619	Henry Savile endows the Savilian Chairs of Geometry and Astronomy Henry Briggs appointed the first Savilian Professor of Geometry
1621	Edward Lapworth appointed the first Sedleian Professor of Natural Philosophy
1624	Henry Briggs's *Arithmetica Logarithmica*
1631	Death of Henry Briggs

Oxford Mathematics

Early mathematics in Oxford

Beginnings

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Although its actual origins are obscure, the University of Oxford can trace its existence back over at least eight hundred years.

Grosseteste and Bacon

Robert Grosseteste

The University of Oxford seems to have come into being gradually during the 12th century as groups of scholars gathered to learn and study together. From its early years Oxford drew upon mathematical influences on its ways of thinking. A seat of Franciscan teaching, it was influenced by a tradition of Christian Neoplatonism, and in this tradition mathematics played an important role as revealing God's design for the Universe.

An early Oxford teacher was *Robert Grosseteste*, who may have been the University's first Chancellor around 1224. In what amounts to a research programme for investigating the world through mathematical (and specifically geometrical) modelling, he wrote:

'The usefulness of considering lines, angles and figures is the greatest, because it is impossible to understand natural philosophy without these… For all causes of natural effects have to be expressed by means of lines, angles and figures…'

Roger Bacon

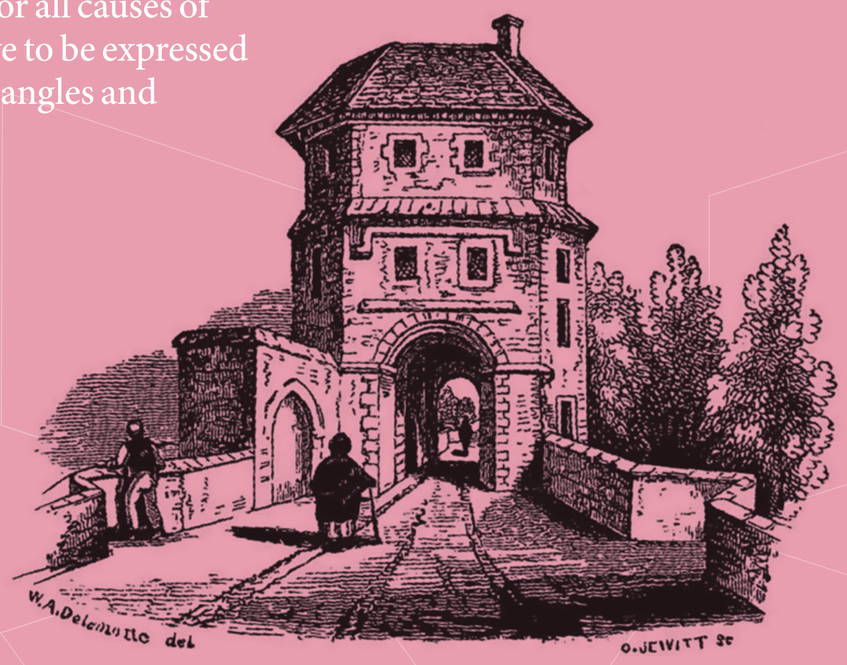
Grosseteste's famous associate, the Franciscan friar *Roger Bacon*, known as Dr Mirabilis, went even further in proclaiming the importance of mathematics:

'He who knows not mathematics cannot know the other sciences nor the things of this world… And, what is worse, those who have no knowledge of mathematics do not perceive their own ignorance and so do not look for a cure. Conversely a knowledge of this science prepares the mind and raises it up to a well-authenticated knowledge of all things.'

Bacon's study and observatory later became a place of pilgrimage for scientists. Samuel Pepys visited it on 9 June 1668, remarking:

'So to Friar Bacon's study: I up and saw it, and gave the man 1s… Oxford mighty fine place…'

It was pulled down in 1779 for road widening.



Bacon's study on Folly Bridge

The Merton School

Some of the most sophisticated mathematical discussions of the Middle Ages took place at Oxford in the 14th century, where mathematics was used and developed along the lines of the programme that Grosseteste and Bacon had advocated. Most of the scholars concerned with this development were Fellows of Merton College, founded in 1264, and the Merton School became celebrated throughout Europe.

Prominent among the Merton scholars was *Thomas Bradwardine*, the most important English mathematician of the 14th century, who showed how the utterances of Grosseteste and Bacon could bear real fruit in the mathematical analysis of nature:

'It is mathematics which reveals every genuine truth, for it knows every hidden secret… Whoever then has the effrontery to study physics while neglecting mathematics should know from the start that he will never make his way through the portals of wisdom.'

Bradwardine's *Geometria Speculativa*, written in Oxford as an aid to students

In the hands of Bradwardine and his fellow scholars the mathematisation of magnitudes went beyond anything thought of in Greek geometry. Members of the Merton School attempted to quantify intensities of light, heat, sound, hardness and density, and even unlikely 'magnitudes' such as knowledge, charity and grace.

In 1349 Bradwardine (along with many other Oxford scholars and at least a third of the population of England) succumbed to the bubonic plague – the 'Black Death' – shortly after being appointed Archbishop of Canterbury. Teaching and learning continued in Oxford, but in a rather depressed state, and it was some three centuries before Oxford regained any of the intellectual vigour of its glorious early days.

Merton College library (late 13th century)

Oxford Mathematics

Early mathematics in Oxford

Instruments

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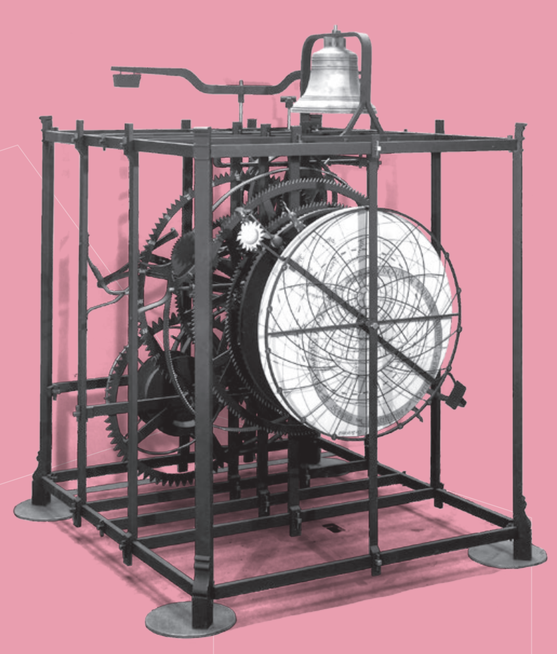
Throughout the 14th century Oxford witnessed a great advance in the development of mathematical instruments for use in astronomy.

Richard of Wallingford

Richard of Wallingford at work dividing a brass disc



A reconstruction of Richard of Wallingford's astronomical clock in St Albans Abbey

Richard of Wallingford studied at Oxford in the 1320s. Perhaps the best English mathematician and astronomer of the Middle Ages, his achievements included the design of an *albion*, a sort of equatorium or planetary computer. This complicated instrument contained over sixty scales of various sorts, and carried a universal astrolabe and an eclipse computer.

In mathematics Richard of Wallingford wrote one of the first comprehensive trigonometrical texts in Europe. After his death his work on the albion was revised by Simon Tunsted, another Oxford scholar, and was influential throughout Europe for several centuries to come.

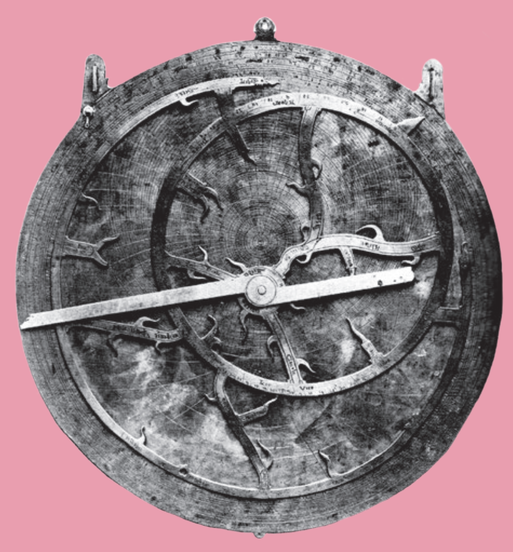
After leaving Oxford he became Abbot of St Albans, where he built a vast and intricate astronomical clock, the first mechanical clock of which we have any detailed knowledge and far surpassing most others for the next two centuries.

Richard of Wallingford's treatise on the theory, construction and use of the albion

Astrolabes

An *astrolabe* is an instrument that was widely used by astronomers, navigators and surveyors in the Europe of the Middle Ages. Once fully developed, it could be used for finding and predicting the positions of the Sun, Moon and stars, for calculating latitude, and for carrying out calculations. The invention of the astrolabe can be traced back to ancient Greece, and during the Islamic age the instrument came into its own, when angular and numerical scales appeared around the rim and a sighting bar was added for use in astronomy.

In Oxford a number of colleges own astrolabes named after them. The following picture shows the Merton astrolabe, dating from about 1360.



Geoffrey Chaucer

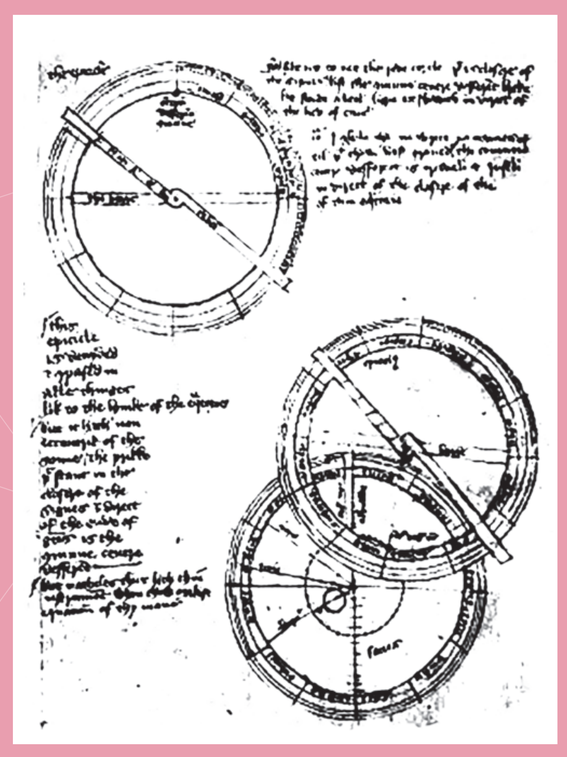
Geoffrey Chaucer had a deep interest in mathematical and astronomical instruments. In *The Canterbury Tales* he tells of Nicholas, a poor Oxford scholar who kept in his lodgings a copy of Ptolemy's *Almagest*, an astrolabe, and counters for making calculations ('augrim-stones'):

His Almageste and bokes grete
and smale,
His astrelabie, longinge for his art,
His augrim-stones layen faire a-part
On shelves couched at his beddes
heed.

Chaucer also provided the definitive image of an Oxford academic, the Clerk of Oxenford:

Of studie took he most cure
and most hede.
Noght o word spak he more than
was nede,
And that was seyd in forme and
reverence,
And short and quik, and ful of
hy sentence.
Souninge in moral vertu was
his speche,
And gladly wolde he lerne, and
gladly teche.

Chaucer also wrote *A Treatise on the Astrolabe*, in which he instructs 'Lowys, my son' to whom he has given 'A suffisant Astrolabie as for our orizonte [horizons], compowned after the latitude of Oxenforde'.



A page from a 1392 manuscript on the equatorium – probably by Chaucer

Oxford Mathematics

Early mathematics in Oxford

The 16th century

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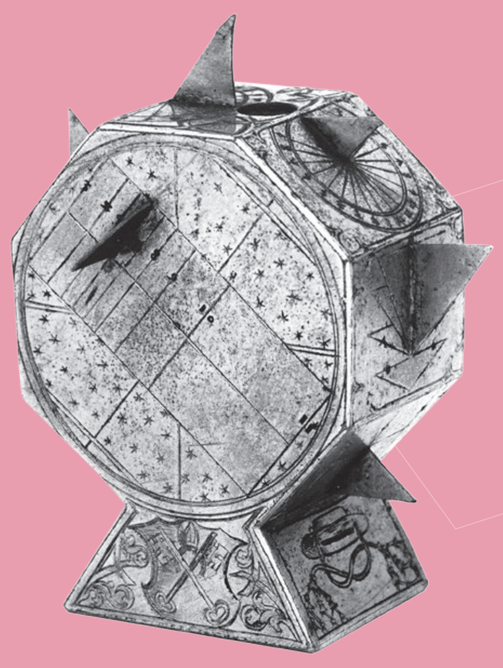
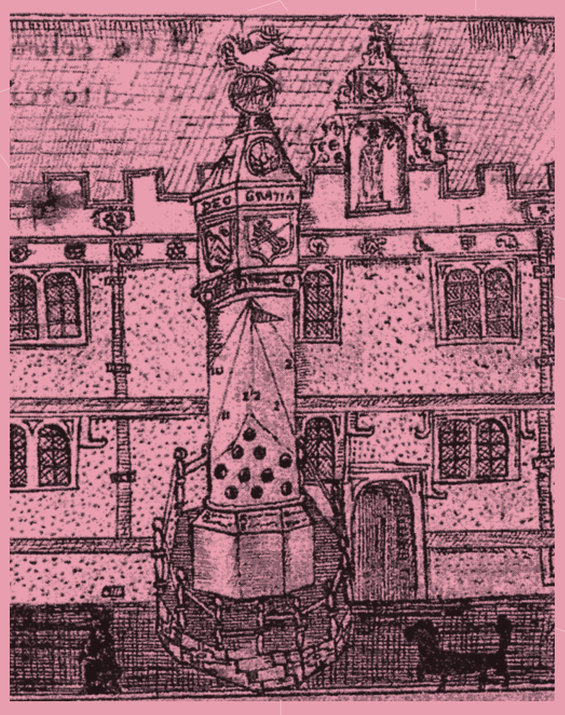
In this century Oxford University helped to provide the practical mathematics needed for navigation, map-making, astronomy and trade expansion.

Sundials and surveying



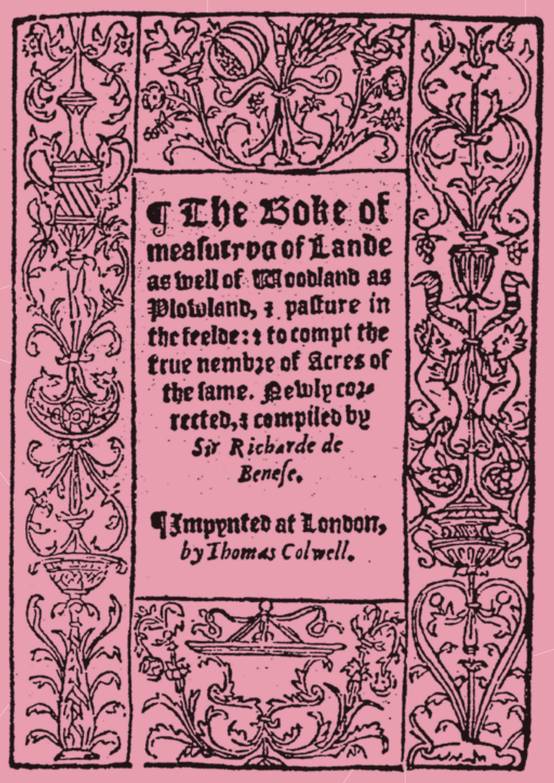
Cardinal Wolsey's portable gilt brass sundial, probably made by Nicolaus Kratzer in Oxford

Around 1520 King Henry VIII and Cardinal Wolsey wished to encourage the teaching of the mathematical sciences. Wolsey founded a mathematical lecture at Oxford, given by *Nicolaus Kratzer*, a Munich-born scholar who became a Fellow of Corpus Christi College and 'Deviser of the King's Horloges'. The 'pelican sundial', designed for that college by Charles Turnbull, was erected in its front quadrangle in 1581.



The 'pelican sundial' at Corpus

Several Oxford scholars of the 16th century were involved with land-surveying. The first surveying book in English, *The Boke of Measuryng of Lande* (c. 1537) was written by Richard Benese, an Augustinian friar who had supplicated for an Oxford law degree in 1519. Books such as this provided the quantitative skills needed for opening up the Tudor land market.



¶ Here foloweth the Booke to measure all Landes.

The title page and a picture of the Greek astronomer Ptolemy from Richard Benese's *The Boke of Measuryng of Lande*

Books

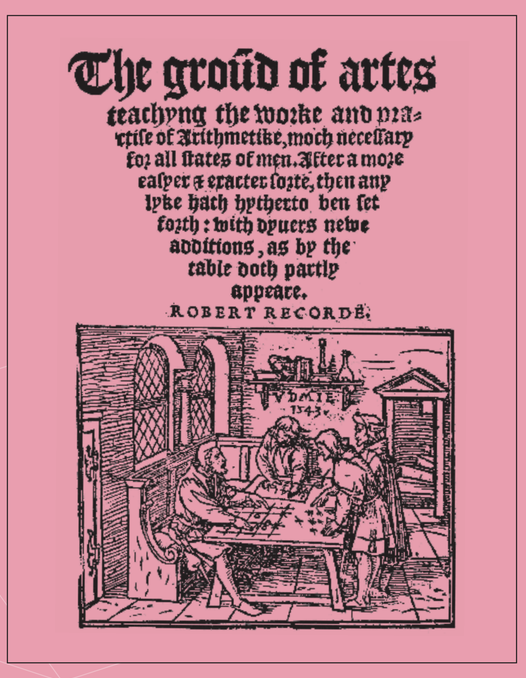
Title page of the *Compotus Manualis*

With the invention of printing in the mid-15th century, mathematics books began to be widely available at a reasonable price. Some were in Latin, such as the *Compotus Manualis ad Usum Oxoniensium* of 1520, Oxford's earliest publication with any mathematical content, which taught its readers how to calculate the dates of the Church calendar on one's fingers. *Cuthbert Tunstall*, who had studied in Oxford, wrote *De Arte Supputandi*, the first arithmetic text to be published in England.

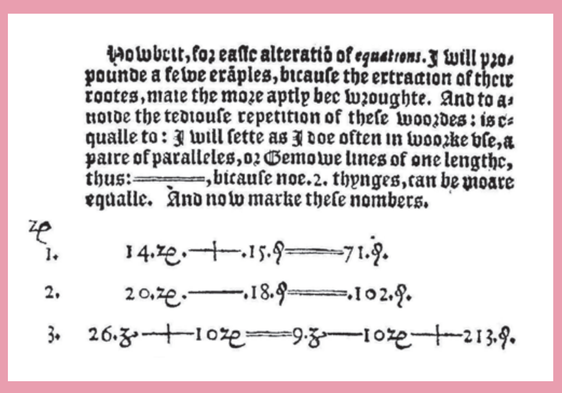
Cuthbert Tunstall

Tunstall's *De Arte Supputandi*

There were also increasing numbers of mathematical texts in the English language. Notable Oxford authors included *Robert Recorde*, who wrote several highly popular textbooks, and *Henry Billingsley*, who published the first English edition of Euclid's *Elements in* 1570.



Robert Recorde's arithmetic text, *The Grounde of Artes* (1543)



The 'equals' sign made its first appearance in Recorde's algebra text *The Whetstone of Witte* (1557)

Oxford Mathematics

Early mathematics in Oxford

Around 1600

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Around 1600 teaching and research were developing in Oxford, while other practitioners were involved with such concerns as navigation.

People

Thomas Allen

Thomas Allen was one of the most influential Oxford scholars from the 1560s until his death in 1632. An avid collector of mathematical books and manuscripts, he contributed to the build-up of the Bodleian Library's fine collection of medieval mathematics and science.

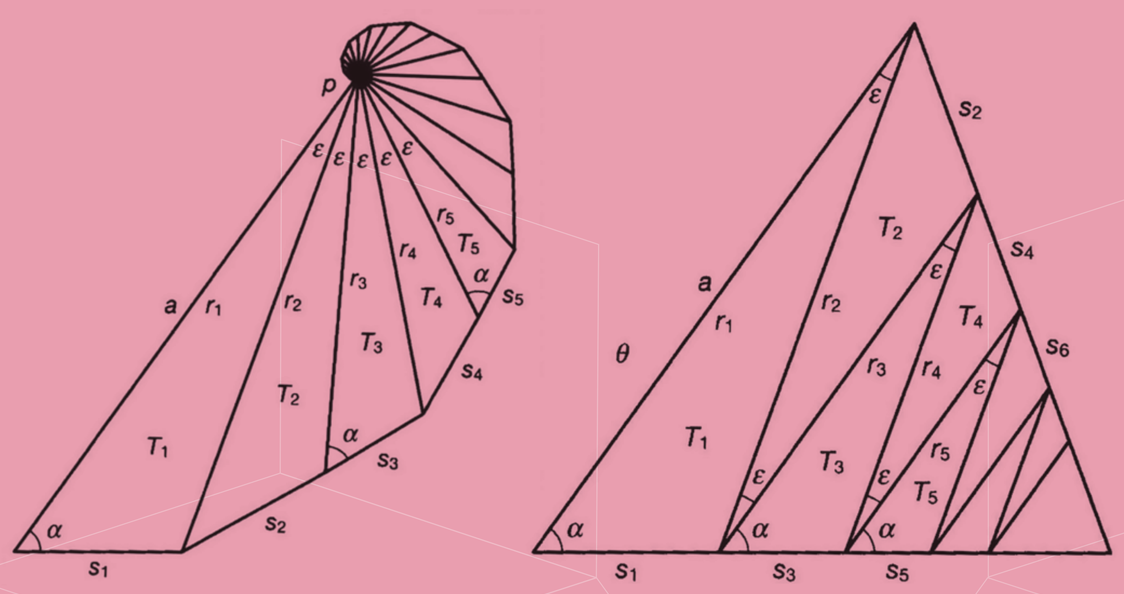
Ralph Kettell, President of Trinity College, was one of Oxford's eccentrics. Disliking long hair he walked around Hall at dinner time cutting any student's over-long locks with a pair of scissors hidden in his muff. Intervening in a geometry tutorial he announced:
I will shew you how to inscribe a triangle in a quadrangle. Bring a pig into the quadrangle, and I will sett the colledge dog at him, and he will take the pig by the eare; then come I and take the Dog by the tayle, and the hog by the tayle, and so there you have a triangle in a quadrangle: quod erat faciendum.

Ralph Kettell

One of Oxford's greatest mathematicians was *Thomas Harriot*, 'by birth and by education an Oxonian'. After taking his B.A. degree at Oriel College, he joined Walter Ralegh's colonising ventures to Virginia and North Carolina, advising him on navigation, astronomy and surveying.

Harriot was a highly original thinker who left over 8000 manuscript pages of his researches into geometry, algebra, optics, mechanics, astronomy and navigation. He was also the first astronomer to use a telescope to map the Moon. Only in recent years have his writings been studied in great detail.

One of Harriot's achievements was to find the length of an equiangular spiral by approximating it by a polygon, cutting it up, and rearranging the pieces into a triangle whose dimensions can be calculated.

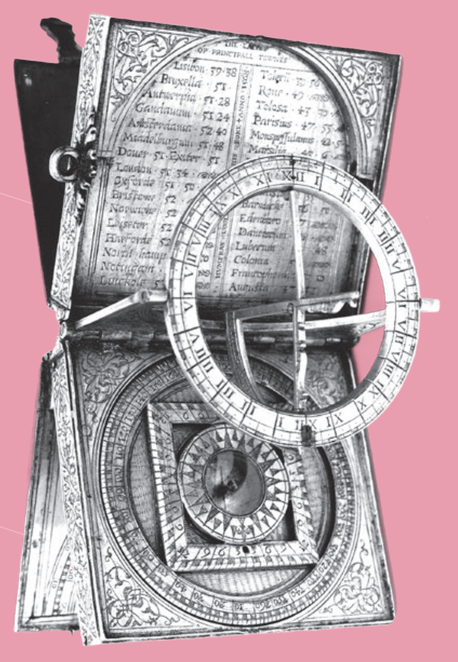


Instruments

At this time of important advances in navigation and astronomy, the need for mathematical instruments of high quality was paramount. The chief instrument makers used by Oxford scholars for their teaching and research were mainly based in London, the pre-eminent instrument-making centre of Europe. Prominent among these were *Thomas Gemini* and *Humphrey Cole*.

In 1559 Gemini made a splendid gilt brass astrolabe for Queen Elizabeth I, who had recently ascended to the throne; it is now in Oxford's Museum of the History of Science. Gemini may have had Cole as a pupil, who in 1568 made an astronomical gilt brass compendium containing a number of measuring instruments. Among the towns whose latitude is given is Oxford (51° 50').

Thomas Gemini's gilt brass astrolabe



Humphrey Cole's astronomical compendium

The Schools Quadrangle

Entrance to the School of Geometry and Arithmetic in the Schools Quadrangle

The Schools Quadrangle of the Bodleian Library was built under the inspiration of Thomas Bodley between 1613 and 1624. The pillars decorating the central tower of the Schools Quadrangle correspond to the five classical orders of architecture.

The Savilian Professors of Geometry lectured in the first floor to the south of the central tower, while the Professors of Astronomy lectured in the first floor to the north. The tower itself was fitted out as an observatory by John Bainbridge, the first Astronomy Professor.

Oxford Mathematics

Early mathematics in Oxford

The world of Henry Savile

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Oxford mathematics from the 1620s was dominated by the legacy of Sir Henry Savile, Warden of Merton College.

Henry Savile

Savile's memorial in Merton College shows him flanked by Ptolemy and Euclid, whose work he expounded in his Oxford lectures

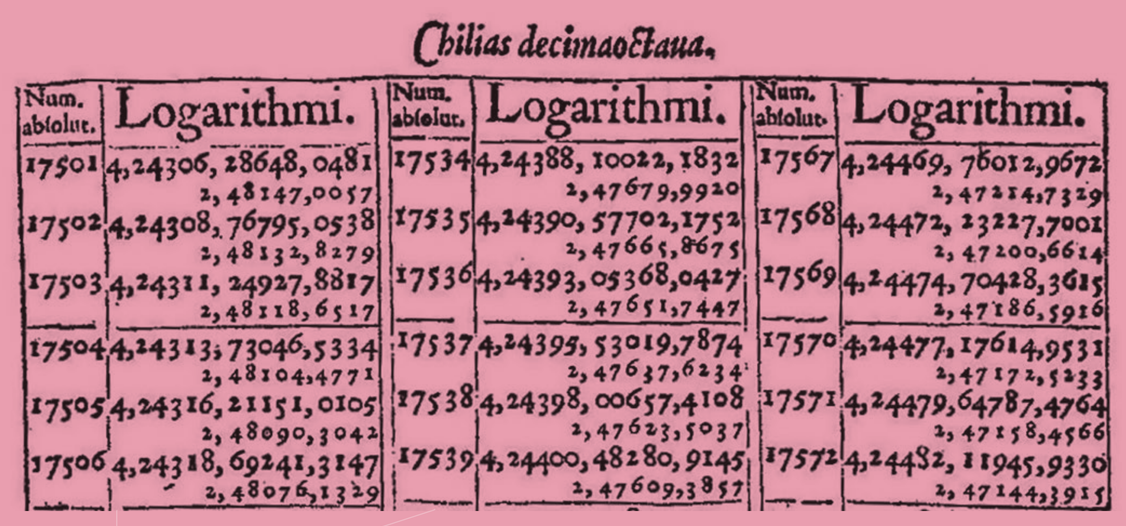
Henry Savile was renowned both for his mathematical abilities and for his encyclopaedic knowledge of ancient texts. A student of Brasenose College, he was elected a fellow of Merton College in 1565 and became Warden in 1585, later concurrently holding the position of Provost of Eton College. He was also a tutor in Greek to Queen Elizabeth I.

Savile was a prolific lecturer and the extensive notes of his lectures on mathematics and astronomy, are an invaluable source of attitudes towards these subjects in Oxford. At a time when mathematics was widely suffering a period of neglect, and when many colleges had ceased to teach it, Savile kept the teaching of the subject alive and well at Merton. His teaching of astronomy ranged from lectures on Ptolemy's *Almagest* to the earliest public teaching in Oxford of the new Copernican system of planetary motion.

The Savilian Chairs of Geometry and Astronomy that Henry Savile endowed in 1619, towards the end of his life, had an unparalleled influence on the institutional structure of Oxford mathematics. The statutes that he composed for these two Chairs not only provided for their maintenance and administration, but also gave very precise details of how the subjects were to be taught. Through these statutes he did more than anyone else to influence the course and style of future mathematics teaching in Oxford.

Two years after the Savilian professorships were founded, Sir William Sedley endowed a Chair in Natural Philosophy. Its first occupant was Edward Lapworth. Several early Sedleian professors held degrees in medicine, while recent holders have been applied mathematicians.

Henry Briggs, the first professor


Chilias decimaoctaua.

Num. absolut.	Logarithmi.	Num. absolut.	Logarithmi.	Num. absolut.	Logarithmi.
17501	4,24306, 28648, 0481 2, 48147, 0057	17534	4,24388, 10022, 1832 2, 47679, 9920	17567	4,24469, 76012, 9672 2, 47214, 7329
17502	4,24308, 76795, 0538 2, 48132, 8279	17535	4,24390, 57702, 1752 2, 47665, 8675	17568	4,24472, 23227, 7001 2, 47200, 6614
17503	4,24311, 24927, 8817 2, 48118, 6517	17536	4,24393, 05368, 0427 2, 47651, 7447	17569	4,24474, 70428, 3615 2, 47186, 5916
17504	4,24313, 73046, 5334 2, 48104, 4771	17537	4,24395, 53019, 7874 2, 47637, 6234	17570	4,24477, 17614, 9531 2, 47172, 5233
17505	4,24316, 21151, 0105 2, 48090, 3042	17538	4,24398, 00657, 4108 2, 47623, 5037	17571	4,24479, 64787, 4764 2, 47158, 4566
17506	4,24318, 69241, 3147 2, 48076, 1329	17539	4,24400, 48280, 9145 2, 47609, 3857	17572	4,24482, 11945, 9330 2, 47144, 3915

Some logarithms from Henry Briggs's *Arithmetica Logarithmica*

In 1614 John Napier of Edinburgh introduced logarithms as an aid to mathematical calculation, designed to replace lengthy computations involving multiplications and divisions by simpler ones using additions and subtractions.

Unfortunately, they were awkward to use, since they corresponded to the equation:
$\log ab = \log a + \log b - \log 1$,
where log 1 had an awkward value.

Henry Briggs was a Yorkshireman who graduated from Cambridge before becoming the first Gresham Professor of Geometry in London. Excited by Napier's logarithms, Briggs felt that they could be redefined so that $\log 1 = 0$ and he twice visited Napier in Scotland to discuss the matter. On returning to London he devised his 'logs to base 10', for which:
$\log ab = \log a + \log b$

In 1624, by which time he had moved to Oxford, Briggs produced his *Arithmetica Logarithmica*, an extensive book containing the logarithms of no fewer than 30,000 numbers, each calculated by hand to fourteen decimal places These proved to be of immense value in navigation and astronomy and led to the development of mathematical instruments based on a logarithmic scale, such as the slide rule.

The appointment of Henry Briggs as the first Savilian Professor of Geometry was not a foregone conclusion. The practitioner Edmund Gunter had devised a number of mathematical instruments, including the Gunter sector and a quadrant, and according to the Oxford antiquary John Aubrey, Henry Savile sent for Gunter,
'who came and brought with him his sector and quadrant, and fell to resolving of triangles and doeing a great many fine things. Said the grave knight, "Doe you call this reading of Geometrie? This is showing of tricks, man!" and so dismisst him with scorne, and sent for Briggs, from Cambridge.'

Henry Briggs was appointed in 1619, along with John Bainbridge, the first Savilian Professor of Astronomy. Briggs occupied the Geometry Chair for eleven years. He died in 1631 and is buried in Merton College Chapel.

These posters were written by Robin Wilson and Raymond Flood, with the assistance of Dyrol Lumbard and Graham Diprose. The text is based on writings by Allan Chapman, Robert Goulding, Willem Hackmann, the late John North and the late John Fauvel.

Oxford Mathematics