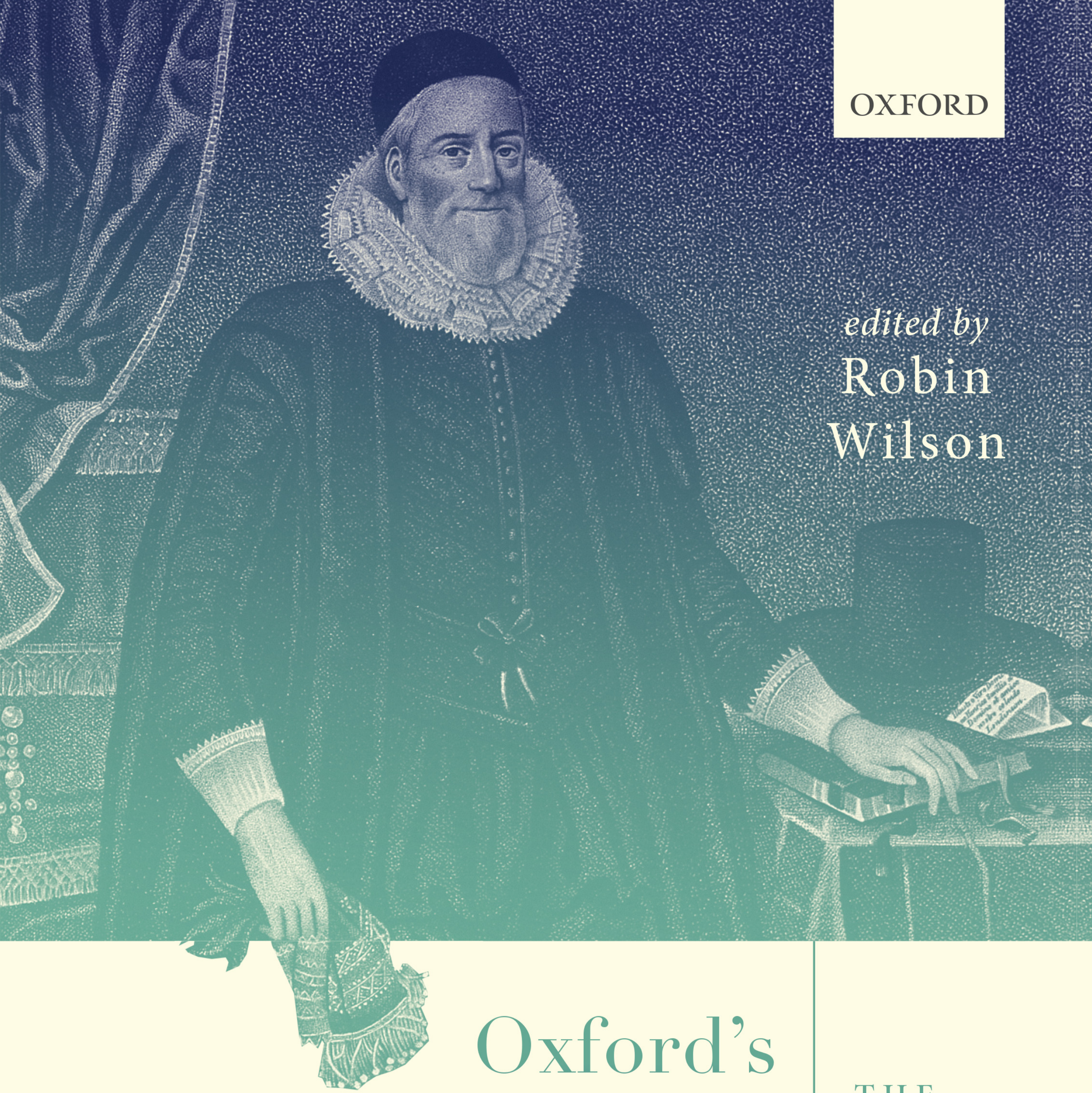

OXFORD

edited by
Robin
Wilson

Oxford's Savilian Professors of Geometry

THE FIRST 400 YEARS

Oxford's Savilian Professors of Geometry

Mathematics in Oxford from the 1620s onwards was dominated by the legacy of Sir Henry Savile (1549–1622). The professorships of geometry and astronomy that he founded in 1619 for 'persons of character and repute, from any part of Christendom, well skilled in mathematics and 26 years of age' were to have an unparalleled influence on the institutional structure of Oxford mathematics.

OXFORD'S SAVILIAN PROFESSORS OF GEOMETRY

The First 400 Years

Edited by

ROBIN WILSON

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP,
United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide. Oxford is a registered trade mark of
Oxford University Press in the UK and in certain other countries

Impression: 1

Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America

British Library Cataloguing in Publication Data

Data available

Library of Congress Control Number: 2021951696
ISBN 978–0–19–886903–0

DOI: 10.1093/oso/9780198869030.001.0001

Printed in Great Britain by
Bell & Bain Ltd., Glasgow

Sir Henry Savile, engraving by R. Clamp, 1796, after
S. Harding after M. Gheeraerts. Wellcome Collection.

FOREWORD

The year 2019 marked the 400th anniversary of the founding by Henry Savile of the Savilian chairs of geometry and astronomy at the University of Oxford. The British Society for the History of Mathematics held a meeting in November 2019 in Oxford's Bodleian Library to celebrate 400 years of Oxford's Savilian professors of geometry, whose number I had the great honour of joining a few years ago. I was delighted to take part in that celebration, from which this volume on the history of the Savilian professors of geometry has developed.

At the anniversary meeting I was asked to talk about the four 20th-century holders of the Savilian professorship of geometry since 1963: Michael Atiyah, Ioan James, Richard Taylor, and Nigel Hitchin. By coincidence I had met them all for the first time within a period of about twelve months, and Richard Taylor, the youngest of them, was the first. Richard and I were both undergraduates at Clare College in Cambridge – not at exactly the same time, but close enough to overlap. I was in my fourth year, taking Part III of the Mathematics Tripos, in 1980–81 when Richard was in his first year. It so happened that Clare's fellow in pure mathematics, S. J. (Paddy) Patterson, had just departed to Germany to become professor of mathematics at the University of Göttingen, and there was no replacement fellow in that year. So I was asked to give supervisions to the first-year undergraduates, including Richard; I remember him as a very impressive student.

At the time that I was teaching Richard, I was wondering what I might do after my Part III in Cambridge. I had enjoyed voluntary work with children as an undergraduate, so one possibility that appealed to me was primary school teaching, and I applied for a teacher training course at Durham University. My interviewers at Durham urged me to consider being a secondary school mathematics teacher, rather than a primary school teacher. On the train journey returning from Durham to Cambridge, I decided that if they really wanted secondary school teachers it made sense to pursue my other option first, which was a PhD degree in algebraic geometry. It had been suggested to me that I should contact Michael Atiyah for advice about this, and so he was the next of the four that I met.

I summoned up the courage to phone Michael on his home number. I think that it didn't occur to me to try to contact him at the Mathematical Institute, and electronic mail didn't exist at the start of the 1980s; I probably just looked up his name in the telephone directory. Although it was nearly lunchtime, it turned out that I had woken him up, as he had just returned from a trip to the United States. I was hugely embarrassed, but he was very kind and invited me to meet him, at which point he gave me a great deal of helpful advice and told me to put his name on my application form if I decided to apply to Oxford. This I did, and I had the enormous privilege of ending up as his DPhil student in the following autumn.

As a DPhil student in the Mathematical Institute, I shared offices with other students supervised by Michael. These included two other Michaels (one now my husband, who had been supervised initially by Ioan James, then Savilian professor of geometry) and also Simon Donaldson (who had been supervised initially by Nigel Hitchin). So I was soon aware of the presence in the department of both Ioan and Nigel, though of course to a lesser extent than that of Michael Atiyah. According to one of his nieces, Michael was known as the quiet member of his family, but that says more about his family than about Michael himself, who was typically to be found talking mathematics with loud exuberance to a colleague, student, or visitor somewhere in the Institute. However, I do remember that very occasionally he seemed stuck for words. When he came into the office I shared with Michael, Michael, and Simon, to summon one of us for a discussion, he would never address us by name but would just look at the relevant person. I have always wondered whether he felt awkward partly because we happened to share his own names (his middle name was Francis), except for Simon (who by chance has my surname as his middle name).

Michael Atiyah was without doubt one of the most influential mathematicians of the second half of the last century; as his former student and collaborator Graeme Segal has said, changing the (mathematical) landscape is what he will be remembered for. Very sadly, Michael died in January 2019, at the start of the anniversary year. I am sure that he would have enjoyed the anniversary celebrations and the opportunity to find out more about his predecessors as Savilian professors of geometry as much as I have done.

Frances Kirwan DBE, FRS
Savilian Professor of Geometry

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Sir Henry Savile's monument in the antechapel of Merton College shows him flanked by Ptolemy and Euclid, the two foundational authorities whose work he expounded in his Oxford lectures.

CHAPTER 1

Sir Henry Savile and the early professors

WILLIAM POOLE

This opening chapter addresses the state of mathematical instruction in Oxford, both before and after the foundation in 1619 of Sir Henry Savile's professorships in geometry and astronomy. After discussing the terms and conditions of his foundations, we situate Savile's benefaction within the general context of Oxford teaching and learning structures. Savile personally appointed his first two professors, Henry Briggs and John Bainbridge, and this chapter discusses their performance and publications, asking what changed with their appointments. Finally, words are offered on their Savilian successors, Peter Turner and John Greaves.

The mathematical scene

In 1619 the scholar and statesman Sir Henry Savile established his two professorships for the University of Oxford, one in astronomy and the other in geometry. It was a great age in that university for charitable endowments, and these were the earliest university chairs in England in the mathematical arts.[1]

They were not entirely novel, however. For a nearby prompt, we need look only to London and the foundation of the professorships at Gresham College, active from 1597

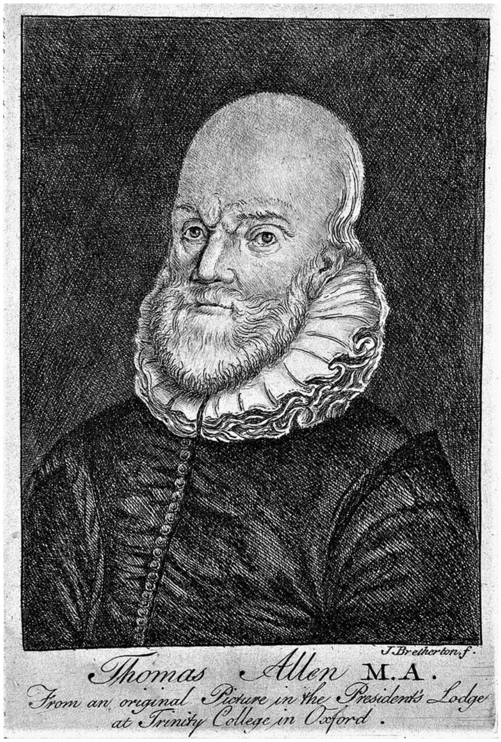
William Poole, *Sir Henry Savile and the early professors.* In: *Oxford's Savilian Professors of Geometry.*
Edited by Robin Wilson, Oxford University Press. © Oxford University Press (2022). DOI: 10.1093/oso/9780198869030.003.0001

and covering seven subjects, including geometry and astronomy. Savile, indeed, would poach his first geometry professor from the Gresham chair. But then, as now, Gresham College neither enrolled students nor awarded degrees.

North of the border, in Scotland, there had been a professor of mathematics at St Mary's College, St Andrews, from 1574. It was moved by Act of Parliament to St Salvator's College in 1579, but the position was not endowed, and lapsed following the death of its incumbent in 1603.[2] The professorship in mathematics at Edinburgh's university (the 'Tounis College') dates from 1620, when one of the four 'regents' in philosophy was given additional duties and salary as the 'public professor of the mathematics', but this got off to a faltering start.[3] In 1612 at Aberdeen, however, the mathematician, astronomer, and royal physician Duncan Liddel (1561–1613) had created six bursaries in arts and mathematics for his *alma mater*, Marischal College, and in the following year he endowed a permanent professorship there in mathematics.[4] This is perhaps the closest earlier British analogue to Savile's benefaction, for Liddel also gave to the college his library, along with an income to purchase annually 'new books of most ancient mathematicks globis and instruments'. But once again, successfully filling the post proved difficult, and Savile's chairs were occupied first.

Henry Savile, however, was not a man to admit precedent. When he resolved upon the two professorships that bear his name, like many a benefactor before and since he found it convenient to exaggerate the problem that he was so munificently to fix. The mathematical arts, he claimed in his deed of foundation, were 'a quarter almost given up in despair', 'uncultivated by our countrymen';[5] and in truth, the Oxford system at least could benefit from his precise intervention. Undergraduates across Europe had in theory always studied a little mathematics: the earliest statutes of Oxford, for instance, mentioned no fewer than five prescribed topics – 'Geometria' (geometry), 'Algorismus' (counting), 'Spera' (the sphere), 'Compotus' (calendrical calculation), and 'Arsmetrica' (measuring).[6] By the late 16th century, the teaching of the mathematical arts in the English universities rested on two complementary institutions: the general college tutor, and the recent MAs, known in Oxford as 'regent masters', several of whom were employed to give public lectures. The problem was that the college tutors might possess only the most basic knowledge, held over from their own undergraduate days, and the regent masters might be little better – it is not so very different from the modern practice of farming out teaching to new graduates.

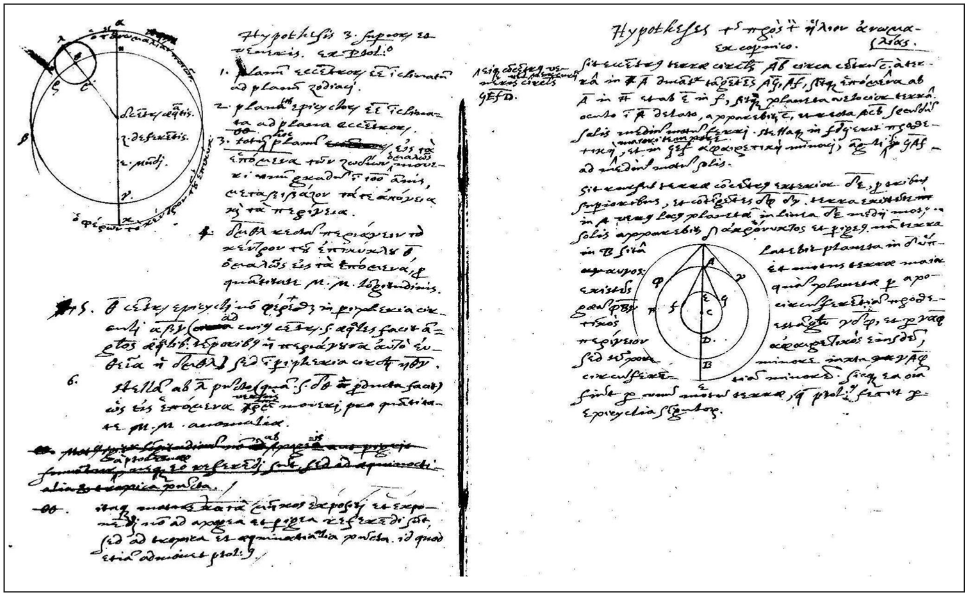
This should not blind us to the possibility that remarkable individuals could still be produced by this fairly minimal regime. The most notable Oxford example in the earlier Elizabethan period was Thomas Allen (BA, Trinity College, 1563; MA, Gloucester



(*Left*) Thomas Allen (1542–1632) of Gloucester Hall (later refounded as Worcester College) was a collector of mathematics books and manuscripts, of which many came to the Bodleian Library.
(*Right*) Erasmus Williams (*fl.* 1590) of New College was a versatile scholar who also mapped College lands. This memorial brass in the Church of St Mary Magdalene, Tingewick, illustrates his interests, including music, astronomy, and geometry.

Hall, 1567), who from the 1560s built up an unparalleled collection of mathematical manuscripts and instruments and taught many a younger mathematician of future note. When he died in his 90s in 1632, his eulogist, William Burton, claimed that when Allen first delivered his required MA lectures in mathematics he had feared that, with the multitude of learned men in attendance, 'the very walls might burst'; Burton then intriguingly contrasted this sharply with the situation in the 1630s.[7]

In the generation after Allen, Thomas Lydiat of New College was one of the few Oxonian mathematicians to be noticed internationally. He specialized in the interrelated fields of chronology and astronomy and, although a biblical literalist and geocentrist, he was happy to propound, before Kepler, the possibility of oval (rather than perfectly circular) planetary orbits. Furthermore, the level of mathematical interest in the later Elizabethan and Jacobean periods can be gauged by book ownership, and here we note



Savile's lectures, the earliest public teaching in Oxford of the new astronomy for which we have evidence, presented both the Ptolemaic (*left*) and Copernican (*right*) models for the Sun's apparent motion.

Erasmus Williams, also of New College, who left his copy of Copernicus's *De Revolutionibus Orbium Coelestium* (On the Revolutions of the Heavenly Spheres) to the College library in his will; it is still there. Finally, there was Savile himself, from Merton College, whose own mathematical lectures as a regent master were (like Allen's) celebrated. He expounded both Euclid and Ptolemy, and also Copernicus.

Lydiat's first published work, the *Prælectio Astronomica* of 1605, derived from lectures given in his college around the turn of the century, and this alerts us to the third development in the time of Savile, the rise of the specialist college lecturer. If the regency system was breaking down – students could pay not to attend – and if the colleges were having trouble fielding adequate general tutors, then perhaps it was time to invent the college-based specialist. Accordingly, by the time that Savile founded his chairs, around half a dozen Oxford colleges were employing bespoke lecturers in mathematics, alongside similar posts in the more traditional subjects, and in some rarer cases, such as at Merton College, in modern languages too.

So, while the colleges were slowly evolving from general to specialist tutors in the mathematical arts, the University itself was stuck on the regency system. Despite the Regius professorships in divinity, Greek, and Hebrew, there was no corresponding foundation for mathematics. Just as the colleges were specializing, so the University needed to do so too; this is the intervention which Savile made, and this is its historical significance. In the words of Seth Ward, the Savilian Professor of Astronomy, in 1654, mathematics was now 'faithfully expounded in the Schooles by the professor of geometry, and in several Colledges by particular Tutors'.[8]

Henry Savile

Henry Savile was a Yorkshireman with a learned father and learned brothers, and was educated from the age of 12 at Brasenose College and then at Merton College, where he became a fellow. He took his MA degree in 1570 and was appointed one of the regent masters in astronomy for the following academic year. His own account of his mathematical development at this time is significant: he started on Euclid's *Elements*, the curricular staple, but switched to Ptolemy's *Almagest* when meeting increasing difficulty in the middle of Euclid's tenth book. Ptolemy in Greek then proved equally hard, and so Savile went back to Euclid, finished it, and returned to complete Ptolemy.

There may be an element of posturing here, for, as a modern authority on Savile has commented,[9] Savile may have been advertising his allegiance to Platonic thought: Plato in his *Republic* had recommended for his ideal citizens a similar plan of study in the mathematical arts, starting with arithmetic, moving from plane to solid geometry, then to astronomy, and finally to harmonics. For Savile was above all a humanist scholar, a student of classical antiquity. Such scholars were interested in three things: producing better editions of surviving texts, establishing the history of their discipline, and recovering lost texts. Accordingly, Savile studied Ptolemy in effect by editing him, and his partial translation into Latin survives among his manuscripts in the Savile collection in Oxford's Bodleian Library. As for the history of his discipline, Savile prepared an ornate biobibliography of all ancient mathematicians, again in a work that he left in manuscript.

Finding new texts was usually facilitated by scholarly travel, and in 1578 Savile, supported by Merton College, set off on a Continental tour that lasted for four years. While travelling, he made friends with several leading mathematical humanists, including Johannes Praetorius in Altdorf, Thaddaeus Hagecius in Prague, and Andreas Dudith and Paul Wittich in Wrocław. During his tour, Savile also made copies of rare manuscripts – for instance, the then unknown and unpublished *Isagoge* of the Hellenistic astronomer Geminus of Rhodes. In Vienna, Savile was pointed to a copy of this text, which he transcribed with his travelling companion George Carew; it is now among the Savilian manuscripts.[10] Savile then moved on to Padua to enjoy the collections and company of Gian Vincenzo Pinelli, humanist, mentor of Galileo, and the major 16th-century Italian collector of printed books and manuscripts. While there, further copies were taken from Savile's copy of Geminus by Pinelli's own scribe.

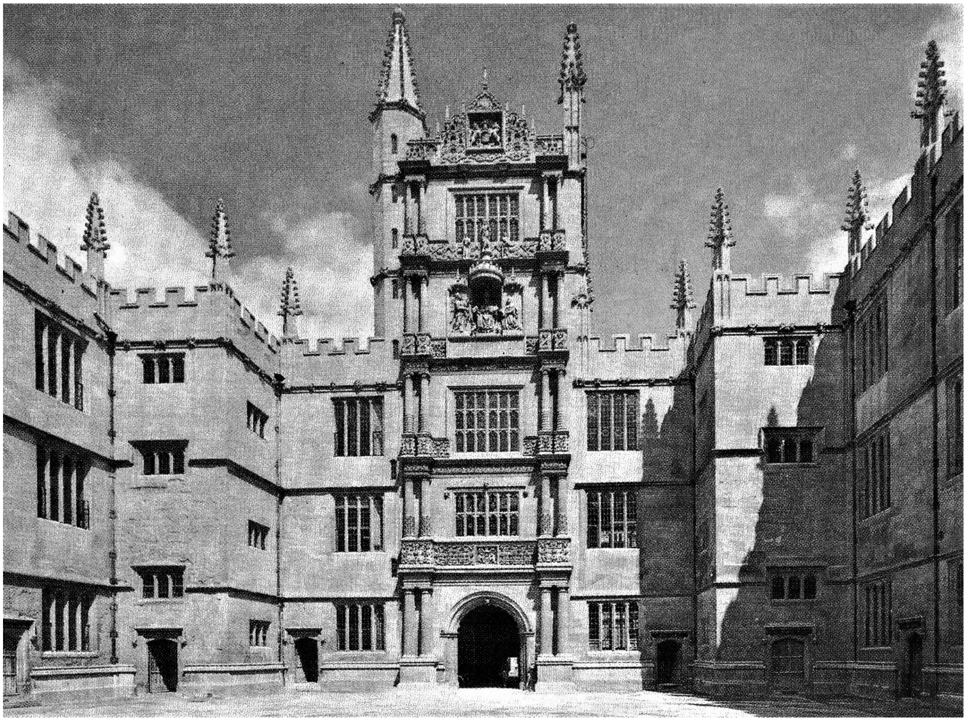
Similar activities on this Continental tour account for several other items today in the Savile collection and elsewhere. We will return to this humanist emphasis, because Savile never really lost it. Nor is it in any way incompatible with Savile's attested interest in Copernicus, who himself advertised his own system as restoring an ancient Pythagorean tradition.

Savile's foundation

Savile's international reputation as a bible translator, a patristic editor, and a scholar and translator of Roman history is not of concern here, but as mathematics was his first love, so it was his last. Instead of founding chairs in his other passions, such as Greek or Divinity, he chose instead geometry and astronomy.

What motivated him? As we stated at the outset, this was an age of benefactors and, as in so many other things, Savile was led here by his friend and older Merton College contemporary Sir Thomas Bodley, the development of whose library, which had opened in 1602, Savile helped to steer after Bodley's death in 1613. If we look at the major endowments in Oxford at this time, in chronological order they comprise Bodley and the Bodleian Library (1602), the Sedleian chair of natural philosophy (bequest of 1618, active from 1621), the Savilian chairs of geometry and astronomy (1619), White's chair of moral philosophy (1621), the Earl of Danby's Botanic or 'Physic' Garden (1621), the Camden professorship of history (1622), the merchant Richard Tomlins's readership in anatomy (1624), the Heather professorship of music (1626), and the Laudian professorship of Arabic (1636). Thomas Bodley lacked a direct male heir, and the bulk of his fortune went to the University. Henry Savile also lacked a direct male heir, as did Thomas White, who had endowed by testament his chair of Moral Philosophy; and William Camden never married.[11] These men were perhaps more focused on legacy than they might otherwise have been.

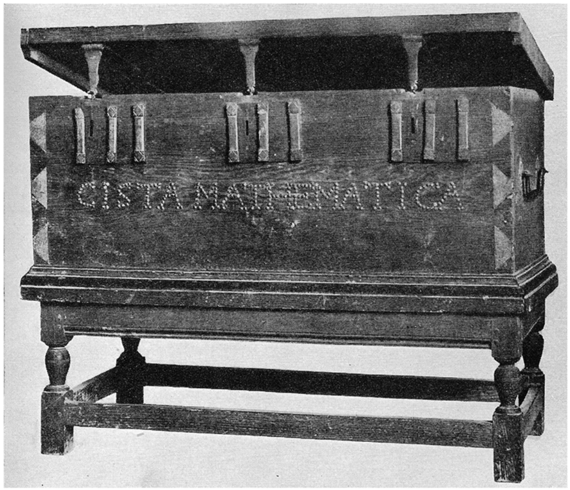
What is also noticeable is the growing specialization of such benefactions, as areas in the chiefly traditional 'arts' curriculum started to be perceived as requiring expert handling at the University level. By Savile's time, the University had no need for professorships in Greek or divinity – it already had such posts – and to make an impact, Savile turned to tidying up the situation in the precise subjects in which he could justly claim status as the English authority.

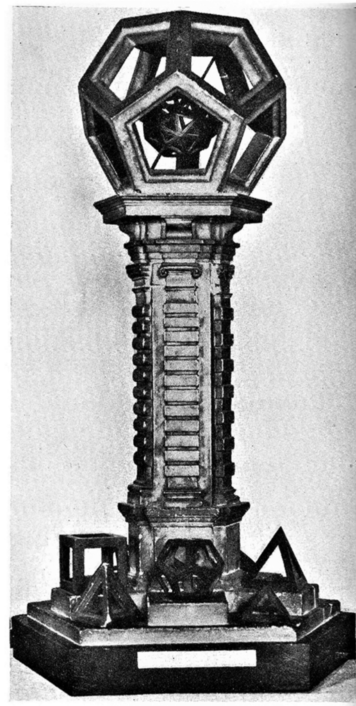


Thomas Bodley's Schools quadrangle was built between 1613 and 1624. The pillars decorating the central tower correspond to the five orders of architecture. On the first floor the Savilian Professor of Astronomy lectured to the north of the central tower, while the Savilian Professor of Geometry lectured to the south. The tower itself was fitted out by John Bainbridge, the first Savilian Professor of Astronomy, as an astronomical observatory.

Henry Savile's foundation was distinguished in several ways. First, his professors were exceptionally well salaried on £160 per annum, the income deriving from lands settled on the University for the purpose. Real income fluctuated with rents, but this statutory income was about three times the basic salary of a Head of House, and fifteen times that of an ordinary Fellow, before augmentations for other College offices. Savile also provided a triple-locked mathematical chest, a bank from which his professors, with University permission, could draw for costs such as the purchase of instruments.

To protect their time for teaching and research, Savile also barred his professors from senior academic or ecclesiastical office. Although, as we shall see, the professors were expected to offer tuition at all levels, their focus, in teaching as in research, was to be on advanced mathematics, it being assumed that College tuition would have furnished the basics. Savile's next innovation was to furnish his professors with a library, complete with a set of mathematical instruments. As he wrote to William Camden when advising him on how to set up his own professorship:[12]





(*Left*) 'Cista mathematica', Henry Savile's chest, was part of his provision for the study of the mathematical sciences at Oxford.
(*Right*) An alabaster model associating the five classical orders of architecture with the five Platonic solids, probably used in the 17th century for geometry teaching.

One thing more I will be bold to persuade you, that to the use of your Readers you would bequeath your Books of that faculty. I for my part have cleared my study of all the Mathematical Books, which I had gathered in so many years and Countreys, Greek and Latin, printed and manuscripts, even to the very raw Notes, that I have ever made in that argument.

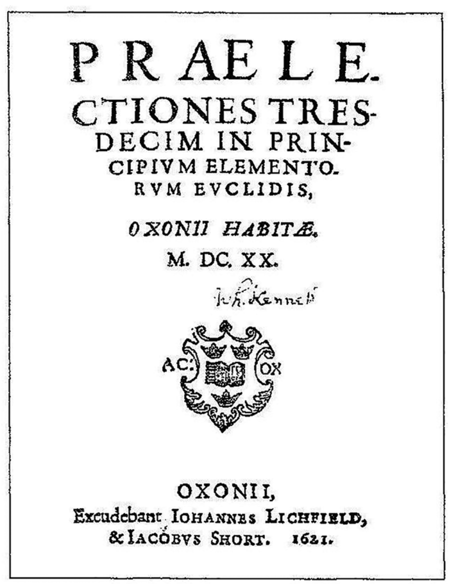
This library is the golden thread that ran through the professional lives of the earliest professors, and we would be justified in seeing many of the major editorial projects undertaken by the professors in this time as intergenerational collaborations – the Oxford 'Euclid' of 1703, for instance, rested on a chain of editorial work that reached back to Savile's own 16th-century annotations.[13]

The next point of interest is Savile's stipulations for lectures. Sticking to the major texts for now, the geometer was required to concentrate on Euclid. The astronomer was to teach Ptolemy, alongside Copernicus and others if he wished, and also (for introductory purposes) 'the sphere of Proclus, or Ptolemy's hypotheses of the planets'. This is a significant detail, to which we shall return.

Finally, there is the issue of 'experimentalism', or the place of practical work under the earliest Savilian professors. Today the professorships could not be more different: the current geometry professor usually works in areas of mental abstraction that are closed to non-specialists, but with the ironic complication that computing now plays a role that Savile could never have imagined; the current astronomy professor deals with the Sun's internal rotation and with telescope arrays that are trailed in space to form vast triangles inscribed in planetary orbits.

So what did Savile say about the relationship between the theoretical and the practical? The evidence here is mixed, and perhaps the best solution is to agree that Savile warmed over time to the importance of practical science, but that he was not himself particularly drawn towards it. Savile's last lectures, on Euclid, were humanist to the final sentence and were concerned more with the history of mathematics – establishing for the first time which of the two historical Euclids (Euclid of Alexandria, rather than Euclid of Megara) was the mathematical author, and continuing with the explication of theorems, rather than with instrumentation or any real-world application.

But despite his notorious dismissal of his first choice for the Savilian Professor of Geometry (described below), Savile's own statutes show that he had come to believe that mathematical instruction ought to include a knowledge of practical or 'mixed'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DECIM IN PRIN-
CIPIVM ELEMENTO-
RVM EVCLIDIS,

OXONII HABITÆ.
M. DC. XX.

OXONII,
Excudebant IOHANNES LICHFIELD,
& IACOBVS SHORT. 1621.

Savile's introductory lectures on Euclid's *Elements* were published in 1621.

mathematics. Among his other duties, the geometer was required to teach land-surveying, while the astronomer had to cover optics, gnomonics, geography, and 'the rules of navigation in so far as they are dependent on mathematics'. The geometer was to lead his students to the fields, and the astronomer was to carry out, record, and archive his observations. Savile even permitted his geometer to offer the most basic instruction in English, a remarkable concession for the time.[14]

Henry Briggs, Savile's first geometer

Savile appointed his first two professors personally. For his geometrician he eventually chose a fellow Yorkshireman, Henry Briggs.[15] Savile delivered the first geometry lectures of his new institution, commencing ceremonially in the Divinity School in Trinity Term 1620, before moving into the new Geometry School at some point in the following Michaelmas Term. At the end of 1620, Savile concluded a series of lectures on the first eight propositions of Book I of Euclid's *Elements* by saying:[16]

Trado lampadem successori meo (I hand the torch to my successor).

So on 8 January 1621, Briggs dutifully took up the torch, starting with the ninth proposition.

Yet Briggs had not been Savile's first choice. A much-repeated anecdote about Savile's foundation concerns Edmund Gunter of London, Savile's initial interviewee:[17]

he first sent for Mr Gunter, from London (being of Oxford University) to have been his Professor of Geometrie; so he 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 [Savile], *Doe you call this reading of Geometrie? This is shewing of tricks, man!* and so dismisst him with scorne, and sent for Henry Briggs, from Cambridge.

This splendid account – it is from John Aubrey and is unverifiable – might be taken simply to mean that Savile still preferred a University theoretician to a metropolitan manipulator of instruments, but some qualifications need to be made.

Briggs, 'from Cambridge' (in terms of his earlier education) was at that point Gresham Professor of Geometry in London – and Gunter was an Oxonian and a senior theologian by academic qualification with a BD degree from Christ Church in 1615. In London, Gunter was close friends with Briggs, who had mentored him and suggested him as successor to the first Gresham Professor of Astronomy (Edward Brerewood), a post that he eventually obtained around the time that he was failing to impress Savile. Furthermore, Briggs was also devoted to the 'resolving of Triangles' and similar practical operations, as we shall see, so the supposed opposition here between the city instrumentalist versus the ivory tower theorist dissolves upon inspection.[18] But for all that, Savile's core bias is apparent. Mixed mathematics might have its uses, but pure mathematics (then synonymous with 'geometry') was still the higher science.

Henry Briggs had been educated at St John's College, Cambridge, gaining his BA degree in 1582 and his MA in 1585. There, 'drawn by a certain propensity of nature', he devoted himself to mathematics, and 'not merely stuck at the bark and surface but penetrated into the marrow and more hidden secrets of those sciences'.[19] His biographer mentions no formal instruction, but Briggs may have been taught by John Fletcher of Gonville and Caius College, who was celebrated for his mathematical ability. Briggs was appointed Cambridge University's Mathematical Lecturer for the year 1587–88 and wrote some commentaries on the geometry of Ramus in manuscript. Bearing the date 1588, these have been identified in modern times and illustrate the kind of mathematics that was offered at university level at that time.[20]

At St John's College Briggs was appointed in mid-1592 to the position of *Mathematicus Examinator* (mathematical examiner). This was a lectureship established by the 1524 statutes of the College, and in theory was held simultaneously by four fellows who were to offer daily lectures over the long vacation for the *Baccalaurei* (the BA students who were reading for their MA degree) in arithmetic, geometry, perspective, and the sphere or cosmography. From the next term he was also appointed to the College's much better paid Linacre lectureship in medicine. Judging from the College accounts, however, it seems as if there was only one mathematical *examinator* by Briggs's time, with the others handling logic and philosophy. But as Briggs was paid 10*s* quarterly, like the other *examinatores*, it seems that one mathematical lecturer now covered all four areas, spaced throughout the academic year.[21]

Briggs certainly taught the young Thomas Gataker who received his BA degree in 1594 and his MA degree in 1597, and who later became a famous scholar.[22] This willingness to offer collegiate instruction remained with Briggs, for when he moved to Oxford over three decades later, he taught arithmetic three times a week to the undergraduates of his new society, Merton College, independently of his Savilian duties.[23] Briggs would happily have remained in Cambridge in the 'shades of the academe' (said his first biographer), had he not been drawn by divine providence to London, the 'theatre of the world'.[24] He did not forget his old College and University, however, and one of his first concerns upon election to the Savilian chair in Oxford was to offer any assistance that he could towards the foundation of a parallel chair at Cambridge.[25]

In 1597 Briggs became the first Professor of Geometry at Gresham College in London, with rooms and a salary of £50 per annum.[26] Savile's later statutes may owe something to the Gresham provisions, for there both the geometer and astronomer were to lecture in Latin in the morning on their appointed day, but in English in the afternoon, and both courses were split throughout the year between theoretical and practical topics.[27] Briggs's earliest publications were all short contributions to other men's works, exclusively comprising tables with the odd explanatory text, and all of them concerned navigation.[28] But this was not really the kind of mathematics where the mathematical humanist Henry Savile's heart lay.

Moreover, on the evidence we have, Briggs spent a great deal of his time engaged in mathematical astronomy. In 1609 he became friends with the great scholar James Ussher, at that point a theologian and churchman in Dublin, and it is deeply regrettable that all but two letters from their apparently extensive correspondence is lost. Their exchanges concentrated on astronomy and chronology, and it was during this period that Briggs set about computing improved eclipse tables.[29] For this purpose he started reading Kepler's works avidly, but with some frustration as he was unsympathetic towards Kepler's cosmology, intolerant of his astrology, and uninterested in his Platonism. Indeed, those who study Kepler's reception in England during this period rightly judge Briggs to have been drawn chiefly by the computational possibilities of Kepler's work. On the slim surviving evidence, Briggs preferred a non-realist position in which, although content with the basic Copernican assumptions, he rejected Kepler's ellipses, electing instead to work on older circular models.[30] He retained his reputation for both geometry and astronomy until his death, and after: a poetic epitaph in Greek on him by the Merton scholar and poet Henry Jacob hailed him as:[31]

βριγγίαδης ζωστήρ γαίης, καὶ σύνδρομος ἄστρων,
᾿Ευκλείδεν φρονέων, καὶ Πτολεμαῖον ὅλους.
(Briggs, the land's girdle, and meeting-place of the stars, mindful of Euclid, and all Ptolemy.)

It is in the latter of Briggs's two surviving letters to Ussher, from March 1615, that we first hear of a new excitement in his scholarly life. For Briggs changed mathematical direction when he discovered the work of the Scottish mathematician John Napier, on logarithms. The logarithm (a Greek word, coined by Napier, meaning 'ratio-number') is a computational shortcut that replaces multiplication by addition, as the sum of the logarithms of two or more numbers is the logarithm of their product. This he encountered in Napier's recent publication on the subject, the *Mirifici Logarithmorum Canonis Descriptio* (A Description of the Marvellous Table of Logarithms) of 1614.

MIRIFICI
Logarithmorum
Canonis deſcriptio,
Ejuſque uſus, in utraque
Trigonometria; ut etiam in
omni Logiſtica Mathematica,
Amplisſimi, Facillimi, &
expeditisſimi explicatio.
Authore ac Inventore,
IOANNE NEPERO,
Barone Merchiſtonii,
&c. Scoto.
EDINBURGI,
Ex officinâ ANDREÆ HART
Bibliopôlæ, CIↃ. DC.XIV.

John Napier's *Descriptio* of 1614.

Briggs, who became obsessed almost to exclusion with Napier's discovery, started lecturing at Gresham College on logarithms, suggested an improved system, wrote to Napier about it, and visited the Scots nobleman at his seat in Merchiston Castle in the summer of 1615 when Briggs had no lecturing duties; he visited again in the next summer, and was frustrated in a third visit only by Napier's death in April 1617. The men evidently got on well – indeed, when they first met, 'almost one quarter of an hour was spent, each beholding other almost with Admiration before one word was spoke'[32] – and Briggs is to be credited with either initiating or consolidating Napier's shift from a variant of natural logarithms to logarithms that were calculated to base 10.

Logarithms define and exploit a connection between arithmetic and geometric progressions. This pleasing idea is a theoretical one, and was laid out in that way by Napier, but astronomers and navigators (their terrestrial equivalents) now had a powerful computational tool for solving trigonometrical problems – precisely the 'resolving of Triangles' for which Gunter had been so mocked by Savile. Whereas Napier's conception of logarithms was kinematic (points moving in space), Briggs was solely interested in numerical techniques – the two men thought about number concepts rather differently.[33] Some sense of Briggs's assumptions about the application of logarithms is given by his comment to Ussher, before he had even opened communications with Napier, that

2	Logarithmi.
1	0000,00000,00000
2	0 3010,29995,66398
3	0 4771,21254,71966
4	0 6020,59991,32796
5	0 6989,70004,33602
6	0 7781,51250,38364
7	0 8450,98040,01426
8	0 9030,89986,99194
9	0 9542,42509,43932
10	1 0000,00000,00000

Chilias decimaoctaua.

Num. absolut.	Logarithmi.	Num. absolut.	Logarithmi.	Num. absolut.	Logarithmi.
17501	4,24306,28648,0481	17534	4,24388,10022,1832	17567	4,24469,76012,9672
	2,48147,0057		2,47679,9920		2,47214,7329
17502	4,24308,76795,0538	17535	4,24390,57702,1752	17568	4,24472,23227,7001
	2,48132,8279		2,47665,8675		2,47200,6614
17503	4,24311,24927,8817	17536	4,24393,05368,0427	17569	4,24474,70428,3615
	2,48118,6517		2,47651,7447		2,47186,5916
17504	4,24313,73046,5334	17537	4,24395,53019,7874	17570	4,24477,17614,9531
	2,48104,4771		2,47637,6234		2,47172,5233
17505	4,24316,21151,0105	17538	4,24398,00657,4108	17571	4,24479,64787,4764
	2,48090,3042		2,47623,5037		2,47158,4566
17506	4,24318,69241,3147	17539	4,24400,48280,9145	17572	4,24482,11945,9330
	2,48076,1329		2,47609,3857		2,47144,3915
17507	4,24321,17317,4476	17540	4,24402,95890,3002	17573	4,24484,59090,3245
	2,48061,9631		2,47595,2692		2,47130,3280
17508	4,24323,65379,4107	17541	4,24405,43485,5694	17574	4,24487,06220,6525
	2,48047,7951		2,47581,1544		2,47116,2662
17509	4,24326,23427,2058	17542	4,24407,91066,7238	17575	4,24489,53336,9187
	2,48033,6286		2,47567,0412		2,47102,2059
17510	4,24328,61460,8344	17543	4,24410,38633,7650	17576	4,24492,00439,1246
	2,48019,4638		2,47552,9296		2,47088,1473
17511	4,24331,09480,2982	17544	4,24412,86186,6946	17577	4,24494,47527,2719
	2,48005,3005		2,47538,8196		2,47074,0902
17512	4,24333,57485,5987	17545	4,24415,33725,5142	17578	4,24496,94601,3621
	2,47991,1389		2,47524,7112		2,47060,0347

(*Left*) Some logarithms from Briggs's *Logarithmorum Chilias Prima*, calculated to 14 decimal places (1617).
(*Right*) Some logarithms from Briggs's *Arithmetica Logarithmica* of 1624.

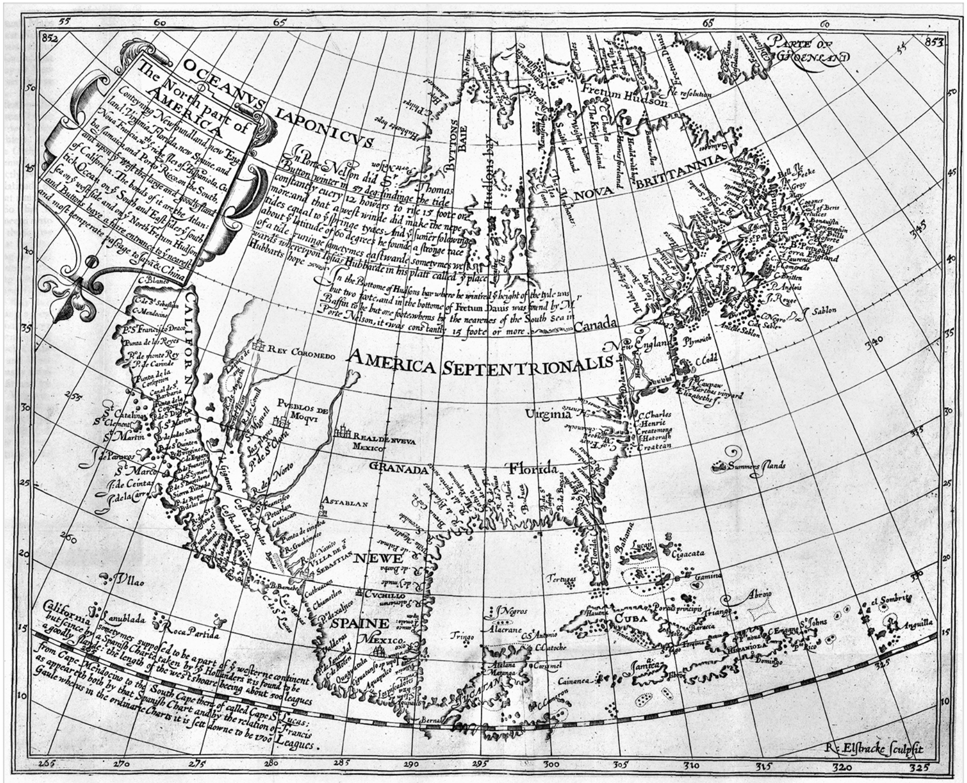
'I purpose to discourse with him concerning Eclipses, for what is there which we may not hope for at his hands'.

Almost all of Briggs's subsequent publications were in the field of logarithms. After first supplying a table for Edward Wright's translation of Napier's *Descriptio*,[34] Briggs published a 16-page pamphlet, entitled the *Logarithmorum Chilias Prima*, which was an initial thousand (or 'chiliad') of his own logarithms to base 10. Tellingly, one of the only four known surviving copies is bound with the Gresham Professor of Astronomy's tables of sines and tangents, Edmund Gunter's *Canon Triangulorum* of 1620, evincing once again the close connection between logarithms and the trigonometry essential for mathematical astronomers and geographers.[35]

In 1624, after years of grinding calculation, Briggs brought to the press his *Arithmetica Logarithmica*, tables of logarithms of numbers from 1 to 20,000 and from 90,000 to 100,000, calculated by hand to 14 decimal places. His own copy has parchment finger-tabs inserted for every thousand numbers, and a few further copies have an extra chiliad at the end.[36] The gap from 20,000 to 90,000 was filled by Adriaen Vlacq of the Netherlands, and the complete set was published in Gouda in 1627, in Latin and French editions, but extending to only ten decimal places. Various translations and vulgarizations followed, but Briggs's remaining mathematical writings were published posthumously by his disciple Henry Gellibrand and printed again in Gouda in 1632 by an associate of Vlacq as the *Trigonometria Britannica*.[37] The Briggs–Vlacq tables had a long and wide afterlife, of which perhaps the most striking instance was afforded by two Chinese editions of 1713 and 1721.

Logarithms simplified trigonometry, trigonometry assisted navigation, navigation promised trade, trade yielded profit, and Henry Briggs carried his interests along that chain. He was a member of (and a significant shareholder in) the Virginia Company, in whose Court Book he appeared regularly from April 1619 to June 1620, being about to leave London for Oxford and resigning his Gresham professorship in July of that year.[38] In 1622, after he had taken up his new position, Briggs's short English essay 'A treatise of the northwest passage to the South Sea, through the continent of Virginia and by Fretum Hudson' was published as an appendix to the colonist Edward Waterhouse's *A Declaration of the State of the Colony and Affaires in Virginia*. It was then republished in Samuel Purchas's famous collection of travel documents in 1625, this time with a map of 'The North part of AMERICA' signed by Briggs.[39] His entrepreneurship persisted: John Aubrey reported (but did not date) a scheme mooted by Briggs to connect the River Thames to the Avon by an artificial canal, and in 1630 Briggs was involved in a bid with Cornelius Drebbel and others to drain the East Anglian counties.[40]

By the time that Henry Briggs was appointed to the Savilian chair, he had become the obvious choice, despite Aubrey's story about Edmund Gunter. He had both academic and metropolitan teaching credentials, an international correspondence, attested interests in astronomy and geometry and in geography and navigation, and he was the prime mover in England of the new art of logarithms. At Oxford he quickly made himself useful within the University, sitting (for instance) on the committee appointed to oversee the newly founded Botanic Garden.[41] He maintained his overseas correspondence, and despite his strong (even puritan) Protestantism he assisted Roman Catholic scholars abroad, for in 1625 he provided *lectiones variantes* taken from the rare transcripts of Geminus to be found among the Savilian manuscripts. Both Henry Briggs and his Savilian colleague John Bainbridge were thanked warmly from Paris by the Catholic convert and librarian Lucas Holstenius, to whom Briggs also wrote in 1626 about his ongoing plans to complete his edition of Euclid's *Elements*.[42] In the late 1620s, Briggs corresponded at length with the Danish mathematician Longomontanus on the latter's doomed attempts to square the circle.[43] He also wrote a short paper in Latin on mathematical discoveries unknown to the ancients for the 1630 edition of a book by his Exeter College colleague George Hakewill. This book, *An Apologie for the Power and Providence of God*, was a kind of collective Oxford statement on modern intellectual achievement,[44] and Briggs headed it with two pieces of astronomy: the Copernican hypothesis, 'multo facilius & accuratius' (much simpler and more accurate) than the Ptolemaic model, and Galileo's discovery of the moons of Jupiter. These were then followed by algebraic and geometrical discoveries, including those of Reinhold and Regiomontanus, Harriot's method of finding the area



Henry Briggs's map of North America in *Purchas His Pilgrimes.*

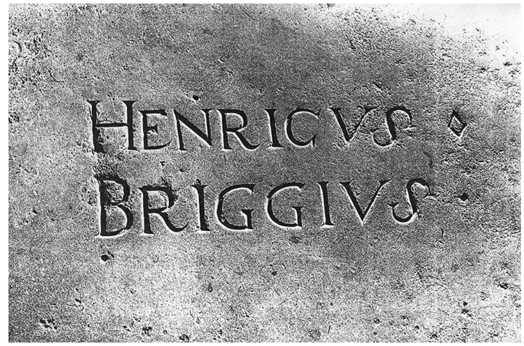
of various shapes, and Napier's logarithms.[45] Again, Briggs assumed the provinces of both geometry and astronomy, with the latter (as ever) under its mathematical aspect, whereas Bainbridge's contribution to the same book provided a short paper in English on the 'supposed removeall of the Sun', a learned piece on the history of such observations that was more oriented to astronomy in its physical aspect.[46]

Briggs's commitment to the practicalities of mathematics is well illustrated by a letter that he wrote in 1626 to Thomas Lydiat, who had proposed a new period of 592 years as a tool for correlating world chronologies. Briggs was politely impressed, but showed himself in favour of persisting with era measures that were either of long standing or widely held, and this led him to remark that the time had finally come to adopt the Gregorian calendar, 'so that trade throughout the whole world may be the more easily plied by merchants' ('ut commercia per universum orbem a mercatoribus commodius exercerentur'). This continued to prove unpalatable to the British for over a century, but Briggs was pointedly aligning himself with the views of John Dee, whose similar proposal the government had charged a committee (which included Henry Savile) with investigating back in the 1580s.[47]

As a Savilian, Henry Briggs evidently lectured conscientiously, and he was a genial supporter of younger mathematicians such as John Pell, both in person and by correspondence.[48] But after his Oxford appointment, his only major publication that was not connected with logarithms was a partial edition of Euclid's *Elements* in 1620, comprising the first six books in Greek with a parallel Latin translation that was a corrected version of the standard one by Commandinus. Briggs's first biographer praised this edition, and it was evidently widely used, as the many copies extant today (often with rather distinguished provenances) attest. But it is a spartan and limited affair, published anonymously, launching straight into the text without prefatory remarks and featuring no commentary or explanations of its textual basis or rationale; moreover, the printed title page makes no mention that only six of the promised thirteen books were to be found there. But Briggs planned to complete this edition, and elsewhere he promised a text collated against two manuscripts and Savile's own adversarial copy. However, he could not find a publisher to take it on, a reminder to us that it was economically difficult to publish mathematical books at this time.[49] Nevertheless, it is a symbolically important publication, for reasons that will become apparent when we come to Briggs's Savilian colleague, John Bainbridge.

When Briggs died, he had set aside by testament some books for the precious Savilian library which he shared and augmented with Bainbridge. These comprise a telling mix of the ancient and the modern, the geographical, mathematical, and chronological: 'Ptolemie his geographie', 'parte of Mercator his great Atlas', 'Petavius de emendatione temporum', and his own works on logarithms with the Vlacq continuation – all remain there today. His testament also demonstrates his continued commitment to navigational discovery: £10 was directed 'towards the discovery of the Northwest passage'.[50]

We conclude our discussion of Briggs's career with a general remark about what changed in Oxford teaching and learning with his appointment. Oxford's regent masters had been young and untested: those formally involved in mathematical instruction were what we would today call 'early career academics'. Most of them would not go on to pursue a mathematical career, because there were then no careers in mathematics to pursue. By the time that Briggs took up his post he was in his late 50s and had already held the only other comparable job in the country. He was again, as we would say, 'a field leader' and held his job in perpetuity from year to year. There was no retirement in this period, only resignation or death. Briggs was able to bring to the job not just his skill,



Henry Briggs's memorial in the antechapel of Merton College.

but also his reputation and his contacts – as we have seen, his overseas correspondents included Kepler, Hondius, and Longomontanus – and it was only with this stability and stature that a subject could successfully 'bed in'.

John Bainbridge, Savile's first astronomer

Briggs's colleague was the younger man John Bainbridge, from Leicestershire.[51] As our focus is on the geometers we comment more briefly on Bainbridge, but we must recall that there was considerable fluidity between the two professorships in the earlier period, in terms of both province and personnel, and a study of either chair in isolation is no history at all.

Like Briggs, Bainbridge had been educated at Cambridge, at Emmanuel College, and like Briggs he also studied medicine, which he pursued to doctoral level and into actual practice. Just as Briggs had performed as Linacre lecturer at St John's College, so did Bainbridge read the corresponding Linacre lecture in Merton College several decades later, simultaneously with his role as Savilian Professor of Astronomy. He was still in his 30s when appointed to the Savilian chair and had just published *An Astronomicall Description of the Late Comet* (1618/19), a work that displayed some tolerance for astrology. This (possibly superficial) interest he would quickly drop and, perhaps not unconnected to this, judicial astrology was despised by both Savile and Briggs – Savile, indeed, had banned its teaching.[52]

Following their appointments, Bainbridge joined Briggs at Merton College, and in Oxford he pursued his twin careers as an astronomer and as a physician, having taken his medical doctorate in Cambridge in 1614. He commenced his duties with a public lecture that was held on the day following Briggs's own inaugural speech.[53] The two men's interests often overlapped: we have seen that Briggs wrote to Ussher to say that he had