Thomas Harriot (1560–1621), Elizabethan man of science

Michael Spivey, Michaelmas Term 2012

If you look near the right-hand end of high table in the hall of this college, you will find a curious portrait of an enigmatic-looking Elizabethan man, balding with a reddish beard, dressed in black with a ruff at the neck. It is in fact a copy, commissioned by the Provost, of a picture belonging to Trinity College, Oxford. In the top corner appears the inscription, "Anno Domini 1602; Aetatis suae 32" (The year of the Lord 1602; his age 32). It is almost the only picture in existence that can be conjectured to show Thomas Harriot, who was an undergraduate in Oxford in the late 16th century. Harriot would have been 42 in 1602, so at first sight the ages don't match. But the portrait we see now is a copy of the picture after it had been cleaned, and a photograph shows that before the cleaning, the age did appear as 42; what's more, X-ray analysis shows that the age has also appeared as 40 or 30 at some time during the history of the painting. One of these ages at least is right for its being Thomas Harriot! More telling though is that the provenance of the picture at Trinity has nothing to link it with Harriot. It's an Elizabethan picture, yes, and it's been at Trinity for some time, but there is no known link between Harriot and Trinity, and no documents to explain how a picture of Harriot came to be there. I think we are forced reluctantly to conclude that this, the only known picture of him, actually shows someone else.

If the portrait is illusory, Harriot himself is elusive in another way, because although he was active as a mathematician and scientist throughout his adult life, he published only one work during his lifetime, and that was more of a prospectus for a colony in the New World than a scientific treatise. Nevertheless, he left behind thousands of pages of manuscript that have provided historians of science with a distinctive insight into the scientific world of the late 16th and early 17th century.

Harriot in Oxford

Thomas Harriot was born in Oxfordshire in 1560, and entered the University of Oxford in 1577. At that time, Oxford colleges were rather smaller in physical size and in numbers of students than they are now, and most students did not aspire to be members of a college, but instead joined an academic hall, such as St. Mary Hall, which occupied the land that now forms the third quad of Oriel: it was absorbed into Oriel in 1902, and the chapel of St. Mary Hall has now become our junior library. So it was that Thomas Harriot matriculated in 1577 as a member of St. Mary Hall, where he remained until

graduating in 1580.

During his time in Oxford, Harriot fell in with the geographer Richard Hakluyt and the mathematician Thomas Allen, and it may have been through them that he was introduced to Walter Raleigh, who had matriculated at Oriel about 10 years earlier, but apparently never came into residence. By 1583, Harriot was employed by Raleigh in London, keeping accounts, assisting with the design of ships, but most crucially advising on navigation and running a navigation school for the mariners employed on Raleigh's voyages.

American adventures

An expedition of Raleigh's to the New World had brought back – as captives or as guests – two native Americans, Manteo and Wanchese. They caused a sensation at court, but Raleigh sheltered them from becoming a public spectacle, and Harriot painstakingly learned their language, invented a phonetic alphabet in order to write it down, and recorded the information they could give him about conditions in America.

Soon Raleigh formed a plan to establish a colony on Roanoke Island, off the coast of what is now North Carolina, and Harriot became a kind of navigational, scientific and linguistic consultant to the enterprise, sailing with the expedition in 1585. The colony was formed too late in the year to plant and harvest a crop, and it was only with the help of the surrounding natives, mediated by Harriot, that the colony was fed over the winter, before being disbanded in a shambles the following year.

It is the Roanoke colony that led to the only work of Harriot's published during his lifetime, *A briefe and true report of the new found land of Virginia,* published in 1588. This pamphlet praises the fertility of the Virginian soil, catalogues the many crops that can be found growing there, and describes the way of life of the natives. It also contains a hymn of praise to the virtues of tobacco:

> *The leaves thereof being dried and brought into powder: they use to take the fume or smoke thereof by sucking it through pipes made of clay into their stomach and head; from whence it purgeth superfluous phlegm and other gross humours, openeth all the pores and passages of the body . . . whereby their bodies are notably preserved in health, and know not many grievous diseases wherewithal we in England are oftentimes afflicted.*

Back in England, Harriot returned to the support of his patrons, first Raleigh then, as his star waned at court, Henry Percy, Earl of Northumberland. Supported by a pension, and given the use of a house in London, Harriot had the luxury of pursuing his scientific studies in whatever direction he chose.

Harriot the scientist

I have time only to mention a handful of his many achievements. He investigated polynomial equations, and found rules that determine how many solutions an equation has, advancing the study of algebra in crucial ways, and also contributing to the mathematical notation used in algebra, including the modern signs for 'less than' and 'greater than'.

He studied map projections, and was able to solve the problem of laying out the latitude and longitude lines accurately on a map in the style of Mercator. The problem is one a first year student could solve today using in-

tegration and logarithms, but neither of these had been invented in Harriot's time; neither had the decimal point, something that makes his manuscript calculations bafflingly hard to follow. The tables of navigational data needed to lay out the map, or to navigate accurately over long distances by compass bearings, were laboriously calculated by Harriot and remained the best available for centuries afterwards. The methods he used to raise numbers only slightly more than 1 to vast powers remain in use today in computer cryptography.

He was the first to draw a map of the moon as seen through a telescope, beating Galileo by six months. He invented binary arithmetic one afternoon when he noticed that the 1, 2, 4, 8 ounce weights he was using for a chemical experiment could be used for addition and subtraction, and wondered if he could do multiplication in binary too. Leibniz would rediscover this fifty years later.

He studied lenses, and in 1602 formulated what we now know as Snell's Law of refraction. Snell discovered it independently in 1621 and didn't publish it either, leaving Descartes to rediscover it and write about it in the *Discourse on Method* in 1637. In point of fact, the principle had been discovered and written down by an Arab astronomer in 984, then forgotten for six centuries. Priority in science is never simple.

These and many other achievements deserve a much fuller account than I can give this evening, but some flavour of the breadth and depth of Harriot scholarship can be gained from the annual lectures on Harriot that have been given in college for the past twenty years and collected by Prof. Robert Fox in two volumes.

Atomism and atheism

In Elizabethan England, doubting the Protestant religion was tantamount to treason, so it became expedient for enemies of Raleigh and later of Henry Percy to suggest that they were, if not actually Catholics, then at least atheists. This suggestion could have weight lent to it by the observation that they had, at different times, employed and supported Harriot, who was interested in reviving the atomic theory of the ancients, long associated with atheism. It didn't help that Harriot also dabbled in alchemy, that most mystical of pseudo-sciences, and was known occasionally to cast horoscopes. For these and other reasons, a reputation for atheism attached itself to Harriot and would persist long after his death.

In thinking about the atomic theory, it is important not to confuse classical atomism with our modern idea of what an atom is. For the ancients, atoms were a metaphysical idea rather than a scientific one, though for Harriot and his contemporaries, the theory did start to have a predictive character, and Harriot did try to explain the refraction of light on an atomic basis. Indivisible and immutable, atoms were the smallest units of a substance, sharing all the properties of the bodies they made up. There was no notion of a chemical compound made up of different atoms, nor that substances could change by chemical reactions. All this makes the ancient idea of atoms share some of the characteristics both of our molecules and of our elementary particles.

There are, I suppose, two reasons beyond mere tradition why atomism should be associated with atheism. One is that if all motion is just atoms moving through the void on predictable paths, then there is no possibility of free will or divine intervention in the world. Rather charmingly, Epicurus

tried to avoid this problem by supposing that atoms can sometimes swerve from their paths in ways that can be affected by the will of God or man.

Rather more important is the idea that, if atoms are indivisible and immutable, then God would not be able to cause the changes needed to create the world from nothing. Much controversy surrounds the question whether Harriot repeated the ancient formula, *ex nihilo nihil fit* ('from nothing is nothing made'), or if he did, what he meant by it. Interestingly, the New Atheists are wont to say that a universe *can* spring from nothing – without, of course, the need for a creator – but their nothing is the new, quantum-mechanical nothing, which is actually not nothing at all. These themes in the perceived conflict between science and religion – whether divine intervention is possible, and whether the world needs a creator – are not some new feature of modern thought, but actually have a history that stretches back through Elizabethan times to classical antiquity.

Evidence of faith

If we cannot rely on reputation to decide about Harriot's faith or lack of it, we should look instead at his writings. The papers left by Harriot provide, if anything, mild evidence of a conventional Christian belief, as well as an interest in specific theological questions that may have been prompted by his patrons. He is known to have prepared a brief for Raleigh's treason trial concerning the rules of testimony in the Hebrew bible.

We can deduce a little more, I think, from the attitudes Harriot reveals in his *Brief and true report*, where he shows a remarkable respect for native American culture and belief, and a desire to view the natives as believing in one supreme god above all others, and to view the fertility of the American soil as reflecting the unfallen state of the country and its inhabitants. Apparently Harriot would read to his native friends from the Bible, translating it into their language as he read, and believing that they would naturally come to embrace the gospel.

More evidence still comes from Harriot's long and excruciating final illness. A small red spot appeared on his nose in 1616, and this gradually changed into a cancerous growth, more likely than not caused by his heavy use of tobacco, making Harriot surely among the first Europeans to die from a smoking-related disease. Despite the best medical attention, Harriot suffered greatly, and lingered in great discomfort until 1621. A letter survives from Harriot to his doctor, de Mayerne, in which Harriot expresses his confidence in God's providence and in the physician as His minister. And lastly, we have Harriot's will, composed three days before he died, which begins as follows.

> *I commit my soul into the hands of Almighty God my maker and of his son Jesus Christ my Redeemer, of whose merits by his grace wrought in me by the holy Ghost I doubt not but that I am made partaker, to the end that I may enjoy the kingdom of heaven prepared for the elect.*