Joseph Harris of Trevecka

Scientist, Artisan, Servant of the Crown

Martin Griffiths BSc, MSc, FRAS
University of Glamorgan
mgriffi8@glam.ac.uk

A major goal of natural philosophy in the early eighteenth century was the search for accurate positional longitude. This quest demanded the most precise instruments and the most meticulous observations in astronomy and geophysics. Joseph Harris strode across these disciplines making a valuable contribution to the studies of astronomy, navigation, horology and magnetic variation. He later served his country by standardising weights and measures of coinage as Assay Master at the Royal Mint. Yet his prowess is little known or acknowledged. This paper describes and examines his life and roles.

The Royal Society of London was instrumental in collating the scientific and technical knowledge emerging in the enlightenment. Its structure of regular meetings, publishing of journals and subsidizing of scientific expeditions placed British science in the forefront of the scientific revolution. Branches of astronomy, navigation, horology and the manufacture of precision instruments were overseen by the Society, which then distributed and applied such knowledge for specific purposes. In the early eighteenth century one of the most prominent problems was the accurate determination of longitude and the establishment of accurate distances within the solar system to test Newton's theory of gravity.

Joseph Harris (*bap*.1704, *d*.1764) of Breconshire, the son of a carpenter and smallholder, gave of his time and energies in the pursuit of all these endeavours. His contribution has been rarely acknowledged or has been lost amongst the stories of great men who made substantial breakthroughs. His life story is a fine example of the cumulative nature of knowledge and the hidden people behind great discoveries.

Early Life

Joseph Harris was born to Howel and Suzannah Harris of 'Trevecca' (originally Trevecka), now Trefecca, a hamlet less than a mile from Talgarth in the former county of Breconshire. The couple went on to have a daughter, Anne and two more sons who would also become famous; Howell for his preaching and establishment of a religious community while Thomas became the Sheriff of Breconshire.

There are no existing records giving further details of the day or month of Joseph's birth but his Christening took place in Talgarth on the 16th February 1703 according to parish records. His grave tablet informs the reader that he was 62 years old when he died. If born in late 1702 or early 1703 this would put him in his sixty-second year at his death in September 1764. However, Morgan Hugh Jones (1873–1930), Sir John Edward Lloyd (1861–1947), Robert Thomas Jenkins (1881–1969) and others state his birth as 1704. It has been postulated that the change over from the Julian to the Gregorian calendar is responsible for the confusion over the difference for Joseph's birth quoted by many authors. In the early eighteenth century the New Year in Britain started on the 25th March and ran until the 24th March the next year, until the Calendar Act of 1750 put the start of each year at the 1st January. This would place Joseph's birth in early 1704 by modern reckoning and Joseph's death should be recorded as being at the age of 60.

Growing up on a small farm, Joseph learned the usual chores of a rural boy before becoming an apprentice blacksmith to his uncle Thomas Powell. This practical training was to pay dividends throughout his career. In his youth he seems to have been a quiet, introverted child who delighted in scientific experiment and observations of natural phenomena around him. He appears to have been something of a tinkerer, enjoying making small instruments for varied purposes, although none now survive. Joseph also seems to have been taciturn and so lost in his own world that the young agricultural workers who formed most of his circle of friends thought him inexplicable and later, insane.[1]

He must have been an avid reader, and although little evidence of his early education survives it is interesting to note that he taught his younger brother Howell at home before Howell became accepted at the grammar school at Llwyn Llwyd run by the independent minister David Price. There is no evidence to suggest that Joseph attended this school though it is known that he contributed to Howell's fees. Howell seems to be the only one of the Harris brothers to be accepted at St Mary Hall College, Oxford; a form of advancement that would require a grammar school education. Nonetheless, Joseph's later works reveal evidence of training in Latin and Greek, the mainstay of classical education at the time, so he must have applied himself to gaining a rudimentary education early or continued to develop such knowledge throughout his life.

Fig. 1a. The memorial tablet to Joseph Harris in Talgarth Church. Photograph by the author.

On 22nd April 1715 a singular event that may have influenced Joseph's life took place across England and Wales; a total eclipse of the sun. From Trefecca the eclipse was only partial, but over 80% of the sun was obscured. The general public across Britain were well informed of this event, as single sided broadsheets were made available at a penny each. Although the weather reported by observers over England was variable, it is possible that Joseph would have glimpsed this phenomenon through the cloud gaps above his home. The Royal Society, including Edmond Halley, awaited reports on the eclipse from the 'curious publick'; it is possible that Joseph even at this early age may have prepared a brief account given his interests, but if so, any such report is now lost.

His demeanour, prowess and knowledge eventually brought him to the notice of the establishment. Thomas Jones of Tredustan brought him to the attention of the local M.P., Roger Jones who encouraged him in his endeavours and gave Joseph introductions to the London Society of Instrument Makers in order that he might further his interests. These in turn introduced him to the Astronomer Royal, Sir Edmond Halley (1656–1742), and Colonel Samuel Shute (1662–1742) the Governor of the Massachusetts Bay Colony, amongst others. At the age of 22, Joseph left the family home for London.

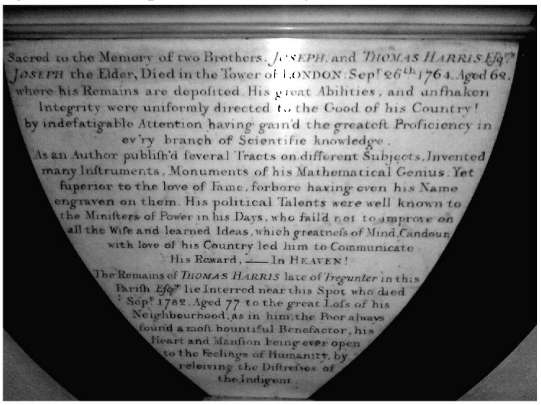

Fig. 1b. Detail of the inscription from the memorial tablet to Joseph Harris. Photograph by the author.

It appears that his decision was motivated both by the attraction of scientific work and also by unrequited love. He had fallen for Ann, the daughter of Thomas Jones who had done much to further his career. However, her rejection of his advances made him determined to leave the area. Some years later she changed her mind and they were eventually married on the 31st October 1736 at the 'Welsh church', St Benet's at Paul's Wharf, London, after his appointment to the Mint; by then Joseph was something of a local celebrity.[2] Together they had a daughter, Anna Maria who eventually returned to the Talgarth area. Joseph maintained strong connections with Trefecca throughout his life.

Training, the Caribbean & the First Publications

In London, Joseph worked with a number of instrument makers such as Thomas Heath (fl.1720–73), Jonathon Sisson (c.1690–1747) and John Coggs (fl.1715–1740) of Fleet Street. It is likely that he was trained by either Heath or Coggs on an informal basis;

he seems to have done some design work that Heath turned into workable instruments. Jones claims that he may have worked for Thomas Wright (1711–1786), but as Wright did not move to London until 1730, this early apprenticeship seems unlikely, although he did make his acquaintance later and dedicated some books to him.[3]

He was also aware of the trade of cartography since Coggs's workshop was also the London address of the map and globe maker John Senex (1680–1740). In 1724 Senex published the Cambridge astronomer William Whiston's *Calculations of Solar Eclipses*, a booklet that would be used by Joseph the following year. During this time as an apprentice Joseph made, refined and improved instruments for use in navigation. He made a new form of azimuth compass able to read magnetic variation to one degree and also designed a more accurate fore-staff for navigational purposes, which was constructed by Thomas Heath.

Joseph was trained by some of the best craftsmen in London in a trade that was to become internationally pre-eminent by the end of the century. They focused on precision instrument making instead of more general scientific instruments, which could be considered the expensive toys of their day. The concentration of clockmakers and instrument specialists in Fleet Street ensured standards of excellence and competitive interplay. They also had their work promoted by the Royal Society where some of the best instrument makers such as George Graham (1673–1751) and James Short (1710–1768) became Fellows.

Joseph's expertise in the production and use of instruments was noted by the Royal Society; his observational and mathematical abilities and the quality of his instruments were subsequently tested on two voyages to the Caribbean; one to Vera Cruz between 1725 and 1727 and another to Jamaica between 1730 and 1732. It is possible that he was financially supported on his first voyage by the Astronomer Royal, Edmond Halley; he sent him at least one letter detailing his observations.

Whilst at Vera Cruz Joseph determined the latitude of the town and made astronomical and navigational observations. A paper detailing his results entitled *Astronomical Observations at Vera Cruz* was published in the *Philosophical Transactions* in 1728. Joseph's contribution to these observations was a collection of data regarding a partial eclipse of the sun on 11th March 1727, and observations of a lunar eclipse on 29th September 1726 which was partly clouded out. This report was read at the Society's meeting by Edmond Halley who noted the accurate determinations of latitude and longitude obtained with a quadrant by the young observer, which corrected the position of the city from its former map location.[4]

The importance of this determination becomes clear because this was the era in which the need for accurate longitude had become a priority. The application of new instruments and accurate mapping was a major motivation for astronomical and navigational science during Joseph's lifetime, and his observations and mathematical dexterity coupled to his skill as an instrument maker enabled him to make a vital contribution to this field.

Joseph's correspondence with Halley indicates another problem he was assessing, the impediment of magnetic variation on compasses, lamenting 'I always found the best observations we could make when compared together differed so much that we could not depend on them to much [better] than three or four degrees and sometime half a point of the compass'.[5] This was a major concern for course-plotting and he made further reference to this problem in his book, *A Treatise of Navigation* (1730).

Returning to London, Joseph collated his experiences in navigation and mathematics and in 1729 published them as *The Description and Uses of Globes and Orreries,* within which he taught navigational techniques in an early attempt to produce a workable system of establishing an observer's position on the Earth. This book may have been a revision of an earlier work by the unrelated John Harris (*c.*1666–1719), who died in 1719. However, Joseph applied his astronomical knowledge to practical problems as can be gauged from reading this work; the first section is an introduction to the Solar System and the stars, filling the first 30 pages of the book; he then revisits celestial positioning many times. The later sections about globes and orreries present positional astronomy, the motions and positions of the planets, in an accessible manner and enable the reader to grapple with navigational and positional problems.

It is interesting to note that amongst the descriptions of the stars of the Milky Way and the constellations, Joseph records that the planets of the Solar System are 'subject to the same laws of motion with our earth, and as some of them not only equal, but vastly exceed it in magnitude, it is not unreasonable to suppose that they are all habitable worlds'. He reveals a familiarity with common scientific speculation of his day and continues in this vein to extend the idea of habitable worlds to planetary systems around other suns also. Though such speculations appear strange now, the idea of extra-terrestrial life across the Solar System was an acceptable premise since the publication of Bernard

Bouvier de Fontenelle's *Conversations on the Plurality of Habitable Worlds* in 1686. Such free conjecture was only reined in (briefly) by the 1854 essay *Of the Plurality of Worlds* by William Whewell, which ruled out the existence of such life on theological grounds. Joseph stayed within a familiar theoretical consensus of his day by ascribing the existence of such life to the magnificence and wisdom of a creator.[6]

He leaves this interesting philosophical discussion to concentrate on the purpose of his text. One of the problems he highlights (problem XXXV) is concerned with measuring the longitude of stars from the first point of Aries and then combining an earlier problem (VII) of global positioning to find an approximate terrestrial longitude, if the rising times in particular places could be standardised. Joseph used mathematical methods to try and acquire longitude by revealing it to be a problem of stellar position from a known meridian, a method that was recommended by the Royal Society and Greenwich Observers. He was keenly aware that such methods demanded continuous clear skies; something of a rarity in Britain, and his next voyage would incorporate early experiments with the use of clocks as potential tools in the hunt for longitude.

Joseph put his advice to good use by making reference to his calculations of the setting times of fixed stars from the Lizard, Cornwall, in 1729. These exercises he wrote up for the publication of *A Treatise of Navigation* in the spring of 1730. The book gained wide approval and was reviewed by the Astronomer Royal Edmond Halley who gained a dedication in the preface. A point of interest here; in an early biographical essay of Joseph the historian M. H. Jones makes the mistake of attributing the fixing of the planet Neptune's position in 1729 to Harris from the Lizard in his, *Treatise of Navigation*. Uranus was not discovered until 1781 and Neptune in 1846. Clearly, this information is incorrect.

The Second Caribbean Voyage

In the summer of 1730, Harris sailed to the town of Black River in Jamaica together with Colin Campbell F.R.S. (died 1752) to conduct further experiments on behalf of the Royal Society. Campbell planned to establish there a permanent observatory equipped with a transit circle and a mural arc of 4 foot radius made by Heath and Sisson; instruments that would enable them to determine a local line of meridian in order to make accurate observations and timings. According to James Bradley (1693–1762), the two men were to 'improve astronomy and promote other parts of Natural Philosophy in that island'. Joseph Harris was engaged as a highly trained assistant to Campbell, a typical employment for someone of talent and ingenuity but lacking the wealth or social connections of the 'gentleman' of the day [7]

Joseph's work there as a scientific assistant included the testing of clocks, recording magnetic variation, and making astronomical observations that repeated the observations of Jovian satellite eclipses noted in 1726 by Bradley. This work was vital in establishing time differences between as many geographical locations as possible to facilitate the calculation of longitude. He also assisted Campbell in observing the sky from their latitude of 18 degrees north (which latitude Joseph established) and acquiring precise celestial positions of the stars in order to complete Halley's *Catalogue of Southern Constellations*, although Campbell never finished this task.[8]

The pair also set up a clock with an isochronal pendulum made by George Graham in order to determine its accuracy in the heat of the tropics. The clock had been set originally for sidereal rather than solar rate in London by using a meridian transit of the star Altair (α Aquilae) and comparisons were made with other timepieces to note any differences. The clock arrived with instructions from Graham on how it was to be set up and what prior experiments had been performed with it in London.

The purpose of this experiment was to test Newton's theory that the force of gravity may diminish with distance from the Equator. Campbell found that the heat lengthened the pendulum and the time slowed at a rate of 9 seconds a day; there was an additional slowing possibly due to other factors. Both observers noted that the clock lost 54 minutes and 21 seconds after 26 days. This phenomenon gave insight into a problem known as the 'Figure of the Earth'.

Up to this time it was assumed that the Earth was a perfect sphere, but meticulous observations of the timing and oscillations of the pendulum of Graham's clock, which could measure seconds, were the basis of calculations to ascertain any departure from a true form. The precise measurements Campbell and Joseph took were communicated in person by Joseph to James Bradley in July 1732, who compared them with readings at Uppsala, Sweden taken by Anders Celsius (1701–1744) and those of Pierre Louis Moreau de Maupertuis's French expedition to Lapland. Bradley was then able to suggest some adjustments to pendulum clocks for different latitudes and tropical heat, and the combined measurements enabled Maupertuis to determine the true shape of the Earth as an oblate spheroid.

During the two years of this expedition Joseph travelled around the Caribbean, and noted local magnetic variation off Florida and Havana using small portable compasses. At Jamaica Joseph drew attention to a phenomenon he independently discovered; diurnal magnetic variation, noting that compasses altered as much as two degrees a day, principally in the forenoon. The phenomena had been recorded by George Graham in London in 1722, but this was the first time it was recorded at another location. It is testimony to Joseph's meticulous work that he noticed it at all since the variation was no more than one or two degrees. Joseph admitted having no idea as to the cause of this occurrence; it has since been found to be due to ionospheric electric currents, though some variations are associated with solar and lunar effects.[9]

Most of the instruments used by Campbell and Harris at Jamaica were sold to Alexander Macfarlane (1704–1755), a merchant, Postmaster-general and judge at Jamaica who wished to improve upon the astronomical observations of Campbell and communicate them to the Royal Society. In the event, Macfarlane made only two known observations; that of a lunar eclipse on the 2nd November 1743 and a transit of the planet Mercury three days later. The instruments were later bequeathed, upon Macfarlane's death, to Glasgow University which in 1760 built an observatory equipped with these instruments. They included a horizontal reflecting zenith sector, a 4-foot mural arc, a 5-foot transit telescope, a portable zenith sector and a one month regulator clock, in addition to miscellaneous lenses, micrometers, compasses, an astrolabe and a camera obscura.[10]

Joseph perhaps took a quiet personal pride in his contribution to these vital scientific activities, although he did communicate the weariness and lack of appreciation of the endeavours both he and Campbell felt when he told Bradley, 'Mr Campbell hinted it some that if something should be said in favour of what we have done, it would be some sanction to him in that part of the world where astronomy is in but little esteem'.[11] It had obviously been a long and arduous expedition carried out in difficult circumstances.

This voyage would be the last time that Joseph travelled abroad. Graham notes that he was taken ill and had returned from the Jamaican expedition earlier than planned. Whatever this illness was, it is not recorded, but malaria is a possibility given that he refers vaguely to 'fatigue or gout' in several letters and mentions it again during his observations of Venus from Trefecca. Although this is a record of an event almost 30 years afterwards, chronic forms of malaria have recurring effects leading to drowsiness or tiredness many years later. Of course various infections and fevers were common in the eighteenth century, and it is possible that Joseph merely suffered from many of the common ailments of his time rather than a tropical disease.[12]

Although there is little further information beyond that found in the *Philosophical Transactions of the Royal Society*, Joseph's writings illuminated his contributions, he must have been an enthusiastic and gifted young scientist. It appears however, that despite his application to his craft he was never invited to become a Fellow of the Royal Society. His later contributions to the *Philosophical Transactions* attribute the epithet of, 'gentleman' to him, without letters after his name as with other authors.[13] Indeed, during his sea voyages his work on observations and the production and use of instruments was as an assistant to the principal observer or leader who was a Fellow of the Society.

More scientific contributions: Navigation, Optics & Advice

On his return from Jamaica, Joseph applied for a post teaching navigation at the naval school at Portsmouth, but did not get it. He then privately tutored mathematics in the household of John Knight M.P. and occasionally taught at the Royal Society's museum at Crane Court, just off Fleet Street, where he reacquainted himself with many of the clockmakers and instrument makers of the day who had shops in this district.

Being in such a position, he was ideally situated to pick up news on the latest scientific and instrumental advances of the time, and his intellectual circle widened to include James Short the famous telescope maker, and also some of London's greatest clock makers including Thomas Mudge (1715–1794) and John Harrison (1693–1776) who would eventually prove the use of clocks in determining longitude accurately. On the 2nd May 1733 (Julian date) George Graham observed a solar eclipse from Fleet Street with a ten-foot focal length telescope. The report was subsequently communicated to the Royal Society and it is more than probable that Joseph would have been interested in this phenomenon and watched the event from Gosfield Hall.[14]

No doubt his occasional teaching duties at Crane Court included demonstrations of the use of scientific and navigational instruments. During this period he came into close contact with the instrument maker John Hadley (1682–1744), vice president of the Royal Society with whom he shared many an interest in this field. Hadley had refined the octant and sextant for navigation and had also built the first reflecting

telescope in an appropriate design for astronomical use. Hadley also sat on the committee appointed by the Royal Society to assess the instruments obtained by Edmond Halley for the Royal Greenwich Observatory and was aware of Joseph's voyages and skills.

Over this same period Joseph carried on a close correspondence with his parents and his brother Howell, and in 1735 came down to Trefecca with the express purpose of dragging his prevaricating brother to matriculate at Oxford. Letters between them reveal the unhappy state of Howell's mind, as he was willing to leave the college and become an itinerant preacher. Joseph was unhappy with this state of affairs; Bennett records that Joseph took a dim view of his brothers preaching activities. Possibly motivated by his association with Thomas Wright and the Royal Society, Joseph appeared inclined towards a more mechanistic and natural view of the world rather than one that included the hand of God. Given what he had written in 1729 it is more than likely that his distaste for Howell's preaching activities may have arisen due to popular perception that such 'itinerants' were outside of the church – the Anglican denomination refusing to accept them as priests. It is probably just concern for his brother, who may have been stepping away from a lucrative career as a country parson that led Joseph to think the negative thoughts Bennett attributes to him. Whatever the position, he encouraged Howell to stay at Oxford and take his degree in theology, even sending him clothes in early 1736 to last the term.[15]

Despite the distractions of sibling life back in Wales, Joseph continued to apply himself to his mathematical and nautical work until 1737 when he was appointed as the Deputy Assay Master of the Royal Mint in the Tower of London. Work at the Mint was exacting and the hours long, but Joseph managed to maintain his scientific interests.

1739 he demonstrated the uses of globes at a meeting of the Royal Society and later wrote up an account for the *Philosophical Transactions*. Joseph showed how to make a horary circle – detailing the hours – intersect both poles of a globe and become moveable about an axis so as to calculate times from a fixed meridian to the east or west and also to make calculable allowances for deviations in latitude. He then 'made some contrivances to shew the effects of the Earth's motions and also adapted it for shewing how the vicissitudes of day and night, and the alteration of their lengths, are really occasioned by the motion of the earth'. The report reveals that Joseph still dabbled in instrument making and other applications, and discloses his ongoing interest in using instrumentation to simplify calculations or to teach difficult concepts, as the article goes on to give an account of a simple machine demonstrating how the annual motion of the earth in its orbit causes the apparent change of the sun's declination; all without the expense of making an orrery.[16]

From 1742 onward he began to amass data for a future book. Joseph initially wanted to limit his optical work to microscopes, but the more he grew interested, the more it expanded into examinations of biology, telescopes and prisms. His interest in astronomical observation led him to write about stellar magnitudes, transparency of the atmosphere, refraction and a host of other details. He also made determinations of the limits of the human eye, delving into biology and experiment to ascertain the optical structures of the eye and measuring its resolving power. He determined that the diameter of the eye was 0.95 of an inch and the distance from the posterior surface of the lens and the retina averaged 6.44 tenths of an inch (16.36mm). From this he worked out that 1 second of arc subtended to 0.000157 of an inch (0.0048mm) on the retina, giving one of the most accurate estimates of visual resolution then available.[17]

He also conducted a series of experiments with a chequer-board of squares one tenth of an inch across and also used a number of horizontal and vertical gratings made of fine wires to ascertain the limits of resolvability and the visual acuity of the eye. Such experiments were also done independently by Tobias Mayer (1723–1762) at Gottingen and by James Jurin (1684–1750) in London. How much collaboration there was between Harris and Jurin is unclear; Harris would have been keenly aware of Jurin as the latter was the secretary of the Royal Society until 1727 and became the president of the Royal College of Physicians in 1750. Even if the two never conversed, Joseph would have been aware of Jurin's extensive experimental accounts in the *Philosophical Transactions* of the Society.[18] His technical expertise enabled Joseph to describe the construction and use of a camera obscura to aid drawing and painting and he included the details of a 'pocket camera' with a 1.5-inch lens that could be fitted to the handle of a cane in order to make a portable instrument for landscape painters. He also gave instructions on a 'perspective box' which could hold a miniature landscape in such a way that the observer would see people through it as if positioned against a distinct romantic backdrop, almost an artist's studio in miniature. It is not known if he actually made any such instruments personally; in all probability his duties at the mint would have overshadowed much of his optical interests.[19]

Nevertheless, Joseph continued to be interested in instruments and clocks. When his brother Howell established the Trefeca religious family – Teulu Trefeca – in 1754, he supplied several clocks for the community and his personal expertise was useful on visits to Trefecca during their setting-up. A principal clock with four faces was established for timekeeping, although whether Joseph had any hand in this particular instrument is open to interpretation – local sources claim it to have been set up by Joseph, but this is not definitely established. Nevertheless the clock became a local curiosity and country squires from many miles around would regularly set their watches by the 'Trefecka Clock'. This instrument, with only one face rather than its original four, is still in the main hall of Trefecca College and still maintains time when wound, over two hundred years later.[20]

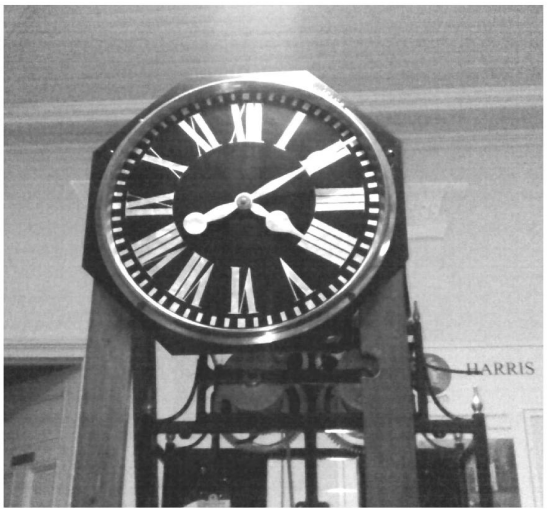

Fig. 2. The 'Trefecka Clock' preserved at Coleg Trefeca.
Photograph by the author.

Lloyd and Jenkins in the *Dictionary of Welsh Biography* claim that Joseph was also the author of several anonymous works on astronomy and mathematics, but it appears to be no longer possible to discover what these works are. Without them it is not possible to accurately ascribe any such work to him.[21] Perhaps Joseph regarded such works as minor, or they may have been exercises that were written up for lectures on natural philosophy to nobles and visiting dignitaries or even for Royal Society meetings. Bryden notes that after Joseph's return from Jamaica he promised to submit more observations 'made with great care' on magnetic variation, but these never materialized. Perhaps it is these notes that Lloyd and Jenkins refer to.[22]

Joseph himself seemed to make little of his increasing fame and regard amid his scientific contemporaries. His diffidence even went as far as his instrument work. In an age where men such as George Graham, Thomas Tompion (1639–1713) and John Coggs were rightly placing their names on their instruments, as they were as much works of art as useful tools, Joseph refused to do so. Inscribed on his plaque at Talgarth church is the phrase 'superior to the love of fame, forbore even having his own name engraven on them'revealing a retiring modesty and contentment that he was part of a larger body of enquiry into nature. Nevertheless, his fame was recognized in the district of his origin. On one of his visits home, his brother Howell describes how walking down the street with Joseph 'filled me with pride that I was in company with such an accomplished person'.[23]

At the Mint

Joseph started working at the Mint in 1736, becoming deputy master in 1737 under Hopton Haynes (*bap.* 1667, *d.*1749) the King's Assay Master. It appears from correspondence that Joseph had been in touch with John Conduitt (1688–1737), master of the Mint and Isaac Newton's nephew through marriage – Sir Isaac Newton (1642–1727) being a former Master of the Mint. Joseph had stayed with Conduitt at his Hampshire home for a month in 1732 and even though Conduitt died in 1737, he had already recommended Joseph to Richard Arundel M.P. who was the new master. Many of the Mint's masters were Royal Society men who would have known of Joseph's attention to detail and meticulous record keeping in addition to his ability as a precision instrument maker. They were also Members of Parliament and had ready access to important economic work through their deputies at the Mint and their ministerial positions. Joseph would prove an ideal choice in an exacting branch of civic work that demanded scientific application.[24]

It is a measure of the trust in him as a person in addition to his abilities that he was appointed, since the statutes of the mint required assayers to be 'professionally competent and regarded with confidence inside and outside the Mint'.[25] There had been an extensive re-coinage under Sir Isaac Newton ten years previously due to the 1707 Act of Union with Scotland and the need for a unified currency. Newton had established the gold standard for coinage, but as yet there was no accurate standard for gold, copper or silver monies. Joseph was appointed as an officer in charge of the accurate measuring of the gold standard, and began to work on establishing a standard for money already in circulation and to institute a new standard for minted coins.

The work was extremely demanding and took a toll of many of its workers. Hopton Haynes, was taken ill in the spring of 1748 and Joseph, as deputy, was left to carry on the tasks alone whilst training an assayer who could take over should he in turn fall ill. By the autumn of 1748 Joseph became Assay Master and he and his wife Ann moved into a larger house in the Tower of London, between the Beauchamp and Devereux towers.[26]

Fig. 3. Devereux Tower, former home of the Royal Mint in the Tower of London.
Photograph by the author.

Part of the Mint's problem was the amount of copper coinage in circulation, and its quality being unacceptable to merchants. At the time of Joseph's joining the Mint, copper coinage could be refused as legal tender if it was tendered in values above 6d. Even by 1757 Joseph laconically remarked that: 'copper coins are not, among us, properly money, but a mere token of exchange'.[27] This problem was partly due to large fluctuations in the value of copper and the flooding of the market with lightweight versions of copper coins minted in various parts of the country. This naturally resulted in the refusal by many merchants to deal in anything other than gold or silver. The situation was so bad in respect to copper coinage that between 1755 and 1779 no copper coin was issued by the Mint. What was needed was a standard for all coinage.

Joseph took this problem head on, but it was apparent to him that the value of coins could only be guaranteed if there were standards that were universally applied. In order to understand and ascribe such a standard he wrote an *Essay on Money and Coins* (part I), which demonstrated that coinage had to be tied to economic stability and the sources of wealth in such a way that money became a standard measure due to its inherent trustworthiness. To achieve such trust, coins would have to be minted from metals that had regulated rates of exchange, i.e. gold and silver.

It became his duty to achieve this. Joseph eventually patented an instrument for the testing of coins that ensured that each minted coin was monometallic, ensured accuracy of individual weight and adhered to a strict regulation. In this way a guarantee of trust was established in standardised coinage. He further reinforced this issue by writing part II of his *Essay on Money and Coins* in 1758; subtitled: 'wherein is shewed that the established standard of money should not be violated or altered

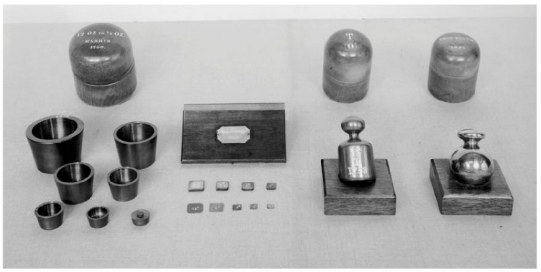

Fig. 4a. Selection of weights by Joseph Harris made for the 1758 Carysfort Commission on weights & measures .
By courtesy of the Science Museum, London.

under any pretence whatsoever'. This book was dedicated to the Chancellor of the Exchequer, Henry Bilson Legge (1708–1764), indicating the high political officers now heeding Joseph's advice. Within each chapter Joseph reveals knowledge of general philosophy and a penetrating insight into its political

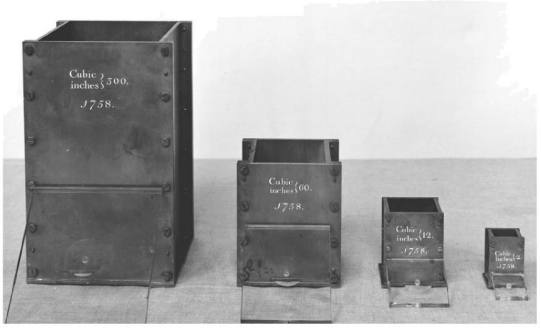

Fig. 4b . Selection of volume measures by Joseph Harris made for the 1758 Carysfort Commission on weights and measures.
By courtesy of the Science Museum, London.

and social application in that he studied John Locke's ideas on 'Monometallism' and applied them to the gold standard.

Joseph received a pension of £300 per year from King George II from 1753 onward. Although now a parliamentary adviser on weights and measures, in his typical modesty he failed to mention the full extent of his involvement to his friends or family. It is known that Joseph had been selected to advise government ministers and prepare reports for the 1758 Carysfort Commission on weights and measures, hence the dedication of his essay on money and coins to Legge is evidence that despite his modesty he was increasingly drawn into the circles of power of his day. Confirmation of his esteem in such circles can be found inscribed on the tablet in St Gwendoline's church: 'His political talents were well known to the

ministers of power in his days, who failed not to improve on all the wise and learned ideas which greatness of mind, candour with love of his country led him to communicate'.[28]

Many of the conclusions reached in part I of *Essay on Money and Coins* presaged the information used later by Adam Smith (*bap.*1723, *d.*1790) in his epochal 1776 volume, *An Inquiry into the Causes of The Wealth of Nations.* Familiarity with Joseph's economic concepts is quite clear within the text; Smith referenced the *Essay* in Book I, Chapter I of *The Wealth of Nations* which borrowed substantially from similar arguments to those Joseph had written nineteen years previously. Such acknowledgement reflects the diversity of Joseph's interests and grasp of many fields of expertise in addition to the trust other scholars placed in his works.[29] Doubtless Joseph felt a quiet contentment that he had made such substantial scientific and political contributions to the life of his country. His modesty forbade him to make more of himself than was necessary and this retiring nature may have resulted in his being passed over for election to the Royal Society. It was sufficient for him to have laboured in these endeavours, leaving posterity to discern what sort of man he was.

The Transit of Venus

Joseph travelled home as regularly as possible to see his brother and to encourage Howell in his agricultural pursuits. Although Joseph himself was probably not particularly religious he found that he could lend an occasional helping hand advising the trades within the growing religious family at Trefecca, and attend some of the early meetings of the Brecon Agricultural Society which he promoted. Although only in his late fifties, Joseph's health was declining; he was suffering from an unidentified recurring illness but passed it off as gout to his siblings. Nonetheless, he still endeavoured to be an active scientific observer and maintain his role as Assay Master at the Mint. An opportunity to become involved in a wonderful celestial spectacle presented itself in 1761. One of the most important scientific events of the eighteenth century was the transit of Venus across the sun, which was predicted to occur on the 6th June that year. Sir Edmund Halley had hinted in 1691 that good observations of such an event from known longitudes would give an accurate measurement of the Earth–Sun distance necessary for improved astronomical calculations of the size of the Solar System. In 1716, Halley called for the Royal Society to coordinate an international endeavour to observe the 1761 Transit event.

Subsequently, this transit became the focus of the first great international scientific effort. History records that the transit was sighted by 121 observers from 66 locations, in places as diverse as Newfoundland and Calcutta. British observers such as Charles Mason (1728–1786) and Jeremiah Dixon (1733–1779) observed the transit from South Africa, whilst John Winthrop (1714–1779) went to St John's, Nova Scotia in Canada, Nevil Maskelyne (1732–1811) studied it on the island of St Helena and Nathaniel Bliss (1700–1764) observed it from Greenwich. Much of the money spent by the Royal Society to participate in this international effort came from John Holles, the Duke of Newcastle.[30] The telescope maker James Short was to collate these disparate observations and compute the results for the Society.

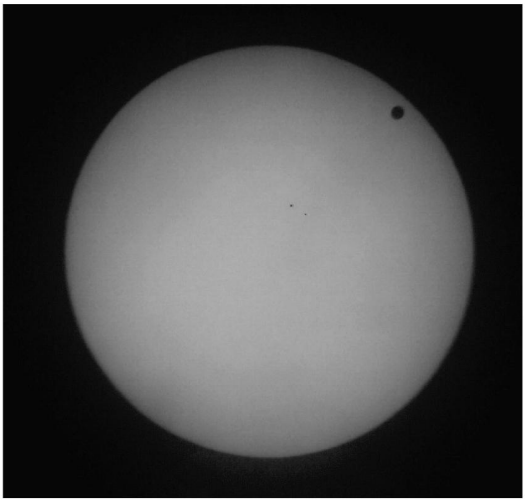

Fig. 5. Photograph taken through a telescope of the 2004 Transit of Venus. Photograph by the author.

Joseph was not going to be left out of this international attempt. Leaving the grime of London behind, he hoped that he could observe this event from the environs of Trefecca and establish the hamlet's longitude in relation to Greenwich. He arrived on the 28th April after dispatching three boxes of mathematical instruments, one of which contained several clocks whilst the other boxes, heavily wrapped in matting, contained a five-foot focal length telescope and possibly a quadrant of some kind. He was the only observer to watch the event from Wales.

To establish the longitude of Trefecca properly, Joseph needed to determine a meridian line based on local noon. He retired to a darkened south facing room over the communal oven at the main building in the community and bored a small hole through a plate fixed to the roof. Then, he inscribed a point on a wooden plank and measured its accuracy beneath the hole with a plumb line, then drew concentric circles

around the central point and drew lines through them all bisecting the circles through the centre point.

Fig. 6a. The reflecting telescope used by Joseph Harris to observe the 1761 Transit of Venus. Photograph by the author.

This method then determined the local meridian and enabled him to set an accurate time on one of his clocks reflecting local noon. The difference between noon measured at Greenwich by one watch and local noon at Trefecca measured by one timed with the meridian line gave him an estimate of longitude. It appears that Joseph had used the transit timings and Halley's parallax tables to determine this initially, and then checked the timings on his return to London.

Fig. 6b. Rear detail of the speculum (metal) mirror from the telescope used by Joseph Harris to observe the 1761 Transit of Venus. Photograph by the author.

His record of the transit shows that he had some difficulty in being prepared for this event. Although he had a good telescope, he records that he had a problem timekeeping because his clock gained 53 seconds in a 24-hour period. Also, the weather was unfavourable and delayed his attempts in setting a proper meridian line to make accurate measurements until two days prior to the event. One is presented with the picture of an old man hastening to make the best he could of an increasingly bad situation between the weather, his instrumentation, perfection in measuring technique and his own health. He reports that on June 6th he 'saw the sun rise and it continued clear the whole morning til past noon. But not being then able to bear much fatigue, I confined my obser-

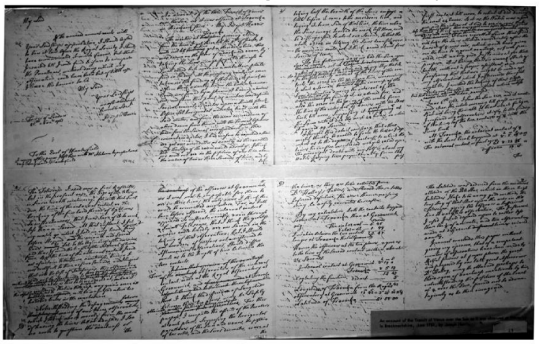

Fig. 7. Letter by Joseph Harris, 'Account of the late Transit of Venus over the sun, as it was observed at Trevecka in Brecknockshire'[31] Photograph by the author.

vations chiefly to the times of the two contacts with the sun's limb'.[31] These were the third and fourth contacts when Venus had already transited the Sun and was now in the last stages of the event. Joseph timed the difference between third and fourth (final) contact to be 18 minutes and 15 seconds. His notes imply that he used the telescope throughout to observe the event, although he does not mention whether the image was projected or seen directly in some fashion. Joseph also admits that he did not take the sun's altitude either, although he confesses to having a good instrument for that purpose while omitting to say what sort of instrument it was.[32]

Upon returning to London, Joseph ascertained the Greenwich timings of the transit event to check the accuracy of his original London timings and confirmed his work on the longitude of Trefecca. He found that there was a difference of 13 minutes and 42 seconds in the timings between each place and from this he calculated that the longitude of Trefecca was 3 degrees 25 minutes and 30 seconds west of Greenwich. He communicated these results by letter in November to George Parker (*c.*1697–1764), Second Earl of Macclesfield then president of the Royal Society. It is possible they were used as part of James Short's computations of the Solar Parallax.

Championing Welsh Culture and Agriculture

Harris's life in London continued in the typical vein of many scientifically inclined men of his time. He would occasionally attend Royal Society meetings, and catch up with family gossip through letters to Howell or by visits to his brother Thomas and his wife and children, who now lived in London working as a

tailor with a shop in the Strand. Thomas became an army uniform contractor, making a fortune from this trade, later returning home to Breconshire and becoming the Sheriff of the county in 1780. Joseph also made visits to Trefecca as frequently as he could, and Howell occasionally visited them both in London during his visits to preach at the Moorfields Tabernacle established by the Methodist George Whitefield (1714–1770). The close relationships they shared as children were maintained throughout their lives.

Joseph was an early member of the Honourable Society of Cymmrodorion, a cultural society set up by Welshmen in London, founded by the brothers Richard (1703–1779) and Lewis Morris (1701–1765) to encourage interest in the literature, science and the arts connected with Wales. The society still meets in London today and is one of the oldest societies highlighting the traditions of Wales outside of the principality. The Cymmrodorion society, under the leadership of the Morris brothers was partly responsible for the 'Welsh Renaissance' of the eighteenth century and Joseph found himself in company with some of Wales's great literary figures of the age. The 'Morris letters' refer to Joseph by name and indicate his generosity to others and his deeds in connection with the Mint. Through this society, the bilingual Joseph met the historian and poet Evan Evans (1731–1788), who would rediscover many old Welsh poems by the sixth century bards Taliesin, and Aneirin. He also encouraged the poet Goronwy Owen (1723–1769), contributing a guinea to him when Owen left Britain to take up a teaching post at New Brunswick in the American colonies.[33]

Outside of London, Joseph was keenly interested in the development of the Trefeca community under his brother's leadership despite his private views on his religious methods.

Davies records that he gave freely of his ideas in the building and administration of the sixty or more trades carried on there.[34] Joseph also encouraged the use of new farming machinery such as seed drills, ploughs and horse hoes, which were coming into service. Joseph was instrumental in assisting Howell with the establishment of the Brecknock Agricultural Society in 1755, the first such society in Britain. This was an important contribution as Britain was undergoing an agrarian revolution which enabled a large increase in crop yield. This was achieved by instituting crop rotation, selective livestock breeding and encouraged the enclosure of lands which was to provide a new pattern of farming for the next two centuries. Utilizing some of these methods, the 'Trefecca family' produced ample foodstuffs and any excess was sold at market. The community was renowned in the locality as industrious wool producers, and Joseph was instrumental in setting up Brecon market in 1756 as an outlet for such activities and to cultivate a market for quality products across the county.[35] Thus Joseph played a small part in the agricultural improvements then assisting the burgeoning Industrial Revolution in which Wales had a central role (see Plate 1a, page 33).

In 1763, the 'Trefeca community' experienced a highlight that was of pivotal importance to Methodism in Wales, the visit of John Wesley (1703–1791), the founder of the Methodist movement. Joseph was probably not in attendance at Trefecca on this occasion as Anne, his wife for more than 26 years, died in March of that year, leaving their daughter Anna Marie to look after him. Joseph was becoming increasingly frail, complaining of attacks of gout and increasing tiredness. In April 1764, he began to collate all his notes and disparate papers on experiments in optics in preparation for a planned book. Joseph had started on this work in 1742, but his duties at the Mint precluded him from finishing the task and he only returned to it at the latter stages of his life. However, he did not see the project through to the end. He died on the 26th September 1764 and his body was interred at the royal chapel of St Peter ad Vincula, in the Tower of London in the tradition of the day for workers at the Mint.[36]

His book was published posthumously in 1775 by B. White, London, as *A Treatise of Optics*. It is in two parts. Book I deals with elementary optics, lenses and the properties of light, whilst Book II returns to his experiments on vision and greatly enlarges upon his earlier experiments and construction of a camera obscura. The book ends suddenly with no real conclusions, almost being a collection of orderly notes, but its mathematical contents are very thorough and it no doubt drew together much of the known optical sciences of his day, possibly adding much on the nature of, and the way in which, vision is perceived via the optics of the eye.

Joseph's Legacy

After Joseph's death his daughter Anna Maria remained at the Mint, or at their alternate London home Place House in Lewisham, for three years until she came of age at 21. Returning to Talgarth, she married Samuel Hughes of Tregunter. She inherited the Tredustan estates of her grandfather Thomas Jones through her mother, and in marrying Hughes united a large portion of privately owned land in the Breconshire area (see Plate 1b on page 33). When Joseph's younger brother Thomas died he left his Tregunter estates to Anna. She had her first child at the late age

of 35 or 36; in June 1784 they baptized a daughter Amelia Sophia. However the estates were inherited by their second daughter, Eliza Ann because Amelia died in 1794.

Eliza married the wealthy landowner Roderick Gwynne of Buckland and had a daughter Anna Maria Eleanor Gwynne who married James Price Holford of Carmarthen on the 4th September 1830. Holford became the Sheriff of Breconshire in 1840. They had a son, James Price William Gwynne-Holford, whose daughter, Louisa Mary Ermine Eleanor Gwynne-Holford, married the chief constable of Monmouth, Edmund Phillip Herbert of Llansantffraed Court Abergavenny in 1865. He was a descendant of George Plantagenet, Duke of Clarence and brother of King Edward IV.[37]

Eleanor died young and is buried, along with her six year old son in the church of St Bridget's at Llansantffraed. Her other son, Edmund Arthur Herbert went to Swaziland and fought in the Boer war as commander of the 6th Inniskilling Dragoons. One of his company commanders was Lawrence Oates who would achieve fame by dying in 1912 with Captain Robert Falcon Scott (1868-1912) in the Antarctic. In 1898 Herbert married Ethel Rogers of Hadlow Castle, Kent, and had two daughters, Eleanora and Mary Catherine Herbert.

Upon Roderick Gwynne's death, Joseph's granddaughter Eliza Ann became the second wife of William Alexander Maddocks MP Maddocks was responsible for building rail links across mid Wales and principally constructing the towns of Tremadoc and Portmadoc in order to transport slate from Blaenau Ffestiniog. Eliza returned home to Brecon after the death of William in Paris in 1828, and their daughter Eliza Anna Maria Ermine Maddocks had the Tregunter estates held in trust until she came of age. She married the landowner John Webb Roche of Rochemont, Ireland.

John Webb Roche was the first cousin of Edmund Roche, 1st Baron of Fermoy in Ireland. Edmund is the great, great-grandfather of Diana Spencer, who upon her marriage to Charles Windsor became H.R.H. the Princess of Wales. Joseph's family connections through his descendents are intriguing. A monarchist through and through, he would have been amused and flattered to have been a distant relationship to William, the future king of Britain.

John and Eliza's sons owned land at Trabolgan in Ireland and it appears from existing archive records that they disputed land at Llysdinam, Newbridge-on-Wye. It seems from census records that they had moved back to Eliza's inherited estates at Tregunter, although these estates contained many outlying agricultural areas across mid and south Wales. John Webb Roche made application for the purchase of the Buckland estate of Anna Maria Eleanor Gwynne-Holford to go to his son Francis William Alexander in 1862. Francis owned Tregunter Park and married Ellen Beatrice de Winton, third daughter of Henry de Winton, the archdeacon of Brecon. He is buried at Talgarth Church and the East window was built in his honour.

Neither he nor his brother John Hughes Roche had any children. Anna Maria married Henry Houlton Palmer Vivian of Tregavethan, Cornwall; a family that had aristocratic connections and lands in Wales through Lord Vivian and Lord Swansea. Henry Vivian was an active member of the Royal Zoological Society and he and Anna Maria moved to his old family residence in Tregavethan, Cornwall after their marriage, which took place at Knuston Hall near Wellingborough, Northants. They had no children and Anna Maria died in December 1881.

Joseph's line of descendants possibly continues through Eleanora and Mary Catherine Herbert, but further research on this line is necessary. Nevertheless, Joseph would have been proud of the civic traditions that his successors and their families contributed.

Conclusion

Joseph once wrote to his brother 'a willing mind and an upright heart are the best qualifications for any undertaking'.[38] No one knew this truism better than Joseph who had lived a full life in science and public duty with no other credentials.

Joseph's contribution to optics, navigation and astronomy should have marked him out as a remarkable and able scientist visible on the world stage. His duties at the Mint changed attitudes towards coinage and laid the foundations of our modern economic system. The Royal Mint that Harris faithfully served is now located in his homeland of Wales at Llantrisant in Glamorgan. However, his reticence and lack of ambition for fame denied him a rightful place in the pantheon of people who have made such a great difference to modern life. Davies notes 'he has not been given, in his native country, the honour he deserved'.[39]

Although his life and work are contained in historical accounts, seldom is there any information which is complete or uncontroversial. Information on Joseph is scrappy, fragmentary and disparate. The author hopes that this paper will encourage future historians to delve a little deeper into the life and contributions of this talented and humble man who did so much to craft the modern world.

Acknowledgements
Martin Griffiths would like to thank the staff of Coleg Trefecca for access to Joseph's telescope and permission to take photographs.

Complete Bibliography of Joseph Harris's Publications

'Astronomical Observations Made at Vera Cruz by Mr Joseph Harris', *Philosophical Transactions of the Royal Society* (1727-1728), 35.

The Description and use of Globes and Orreries, to which is prefixed by way of an introduction a description of the Solar System (G. Hawkins, London, 1729).

A Treatise of Navigation (G. Hawkins, London, 1730).

'Account of some Magnetical Variations made in the Months of May June and July 1732 in the Atlantick or Western Ocean; As Also the Description of a Water-Spout, by Mr. Joseph Harris. Communicated by Mr. George Graham, F.R.S. (January 1, 1753), Harris, J.; Graham, G.', *Philosophical Transactions of the Royal Society* (1733-1734), 38, 75–79.

'An Account of the Improvement on the Terrestrial Globe', *Philosophical Transactions of the Royal Society* (1739-1741), 41, 321–326.

An Essay on Money and Coins Parts I and II (G. Hawkins, London, 1757).

A Treatise of Optics (B. White, London, 1775 – Posthumous)

References

1. Bennett, R., *The Early Life of Howell Harris* (Banner of Truth Trust, 1962), p. 4.
2. Bennett, R., *Howell Harris and the Dawn of Revival* (Evangelical Press of Wales, 1987), p.15.
3. Jones M. H., 'Joseph Harris: An Assay Master of the Mint', *Journal of the Welsh Bibliographical Society* (July 1929), 3 (6), 256-67.
4. Halley, E., 'Astronomical Observations at Vera Cruz by Mr Joseph Harris', *Philosophical Transactions of the Royal Society* hereafter *Phil. Trans.* (1735), 35, 388-89.
5. Halley, E & Harris, J., 'Astronomical Observations made at Vera Cruz by Mr. Joseph Harris revised and communicated by Edmond Halley', *Phil. Trans.* (1728), 35, p. 389.
6. Harris, J., *The Description and use of Globes and Orreries* (G. Hawkins, London, 1730), 29-30.
7. Bryden, D.J., 'The Jamaican Observatories of Colin Campbell and James Macfarlane FRS', *Notes and Records of the Royal Society of London* (1970), 24 (2 April), 261–72.
8. Campbell, C., 'An Account of Some Observations Made in London, by Mr. George Graham, F.R.S. and at Black River in Jamaica, by Colin Campbell, Esq; F. R. S. concerning the Going of a Clock; In Order to Determine the Difference between the Lengths of Isochronal Pendulums in Those Places. Communicated by J. Bradley, M.A. Astr. Prof. Savill. Oxon. F.R.S.', *Phil.Trans.* (1734), 38, 302-14.
9. Harris, J & Graham, G., 'An Account of some Magnetical Observations Made in the Months of May, June and July 1732 in the Atlantick or Western Ocean; Also the Description of a Water-spout by Mr Joseph Harris, communicated by Mr George Graham F.R.S.' *Phil. Trans.* (1733), 38, 75-79.
10. Bryden, D. J., 'The Jamaican Observatories of Colin Campbell and James Macfarlane F.R.S.', *Notes and Records of the Royal Society of London* (1970), 24 (2 April), 261–72.
11. Stearns, R. P., *Science in the British Colonies of America* (University of Illinois, 1970), p.375.
12. Campbell, C., note 8.
13. Harris, J., 'An Account of an Improvement on the Terrestrial Globe by Joseph Harris, Gentleman', *Phil. Trans.* (1739), 41, 321-26.
14. Graham, G., 'An Observation of the Eclipse of the Sun on May 2, 1733 in the Afternoon by Mr. George Graham, F.R.S. in Fleet Street London made with a Telescope of Ten Feet in Length, Fitted with a Micrometer', *Phil. Trans.* (1733), 38, p. 113.
15. Bennett, R., *Howell Harris and the Dawn of Revival* (Evangelical Press of Wales, 1987), 32-39.
16. Harris, J., 'An Account of an Improvement on the Terrestrial Globe', *Phil. Trans.* (1739), 41, 321-26.
17. Harris, J., *A Treatise of Optics* (G. Hawkins, London, 1775).
18. Wade, N., *Visual Neuroscience before the Neuron* (Perception, 2004), 33, 869-89.
19. Harris, J., note 17.
20. Davies, G., 'Trevcka (1706–1964)', *Brycheiniog* (1971), 15, p. 2.
21. Lloyd, J.E., & Jenkins, R.T., *Dictionary of Welsh Biography* (University of Wales Press, reprint, 1992).
22. Bryden, D.J., note 7.
23. Davies, G., 'Trevcka (1706–1964)' *Brycheiniog* (1971) 15, 3-4.
24. Craig J.,'The Royal Society and the Royal Mint', *Records of the Royal Society of London* (1964), 19 (2 December), 156-67.
25. Challis, C. E., *A New History of the Royal Mint*

(Cambridge, University Press, 1992), p. 407.
26. Ibid., 406-407.
27. Matthias, P, *The Transformation of England: Essays in the Economic and Social Transformation of England in the Eighteenth Century* (Univ. paperbacks, London 1979), p. 194.
28. Chambers, L.G., *Report from the Committee appointed to enquire into the original Standards of Weights and Measures* (House of Commons, June.1758), p. 49.
29. Smith, A. *An Inquiry into the Nature and Causes of the Wealth of Nations* (Oxford paperbacks, 2008).
30. Ronan, Colin, *Edmond Halley: Genius in Eclipse* (McDonald & Co, London, 1970), 113-17.
31. Harris, J., 'Account of the late Transit of Venus over the sun, as it was observed at Trevecka in Brecknockshire', *Trefecca* (MSS November 1761).
32. Letter from Joseph Harris to his brother Howell Harris, Welsh National Library Archives, Aberystwyth (1761).
33. Owen, H., 'Additional Letters of the Morrises of Anglesey', *Honourable Society of Cymmrodorion* (1947-49), 2, p. 981.
34. Davies G., note 23, p. 4.
35. Jones, M H., 'Joseph Harris: An Assay Master of the Mint', *Journal of the Welsh Bibliographical Society* (1929), 3 (6 July), 256-67.
36. Ibid., 256-67.
37. Ruvigny Marquis of, 'The Plantaganet Roll of the Blood Royal (Heritage Classics, London, 1911).
38. Jones, M.H. 'The Trevecka Letters', or, The unpublished MSS correspondence of Howell Harris and his contemporaries: an inventory of the letters with a digest of their contents to illustrate certain old and new features of the religious and social awakening in Wales during the 18th century', Welsh Calvinistic Methodist Church, Caernarvon: 1932, MSS xviii, p. 4.
39. Davies, G., note 23, p. 1.

The Author

Martin Griffiths is a senior lecturer in Astronomy at the University of Glamorgan and has written or contributed to over 100 published science articles for many journals. He holds a BSc in Astronomy & Science Fiction and a MSc in Science Communication. Martin is a Fellow of the Royal Astronomical Society and a member of several historical, astronomical and science communication societies. He is a recipient of the Astrobiology Society of Britain's Public Outreach Award (2008) and the Astronomical League's Outreach Master Award (2010).

Martin was one of the founder members of NASA's Astrobiology Institute Science Communication Group, which was active 2003–6; he also managed a multi-million pound ESF programme in Astrobiology for adult learners across Wales 2003–8. He currently teaches on the BSc Observational Astronomy award at the University of Glamorgan and adult education courses through the University of the Heads of the Valleys Initiative.

Plate 1a. The main buildings at Coleg Trefeca, Trefecca, Wales.
Photograph by the author.

Plate 1b. Llantsantffraid Court – the home of some of Joseph Harris's descendants.
Photograph by the author.