

The history of Newton's apple tree

(Being an investigation of the story of Newton and the apple and the history of Newton's apple tree and its propagation from the time of Newton to the present day)

R. G. KEESING

This article contains a brief introduction to Newton's early life to put into context the subsequent events in this narrative. It is followed by a summary of accounts of Newton's famous story of his discovery of universal gravitation which was occasioned by the fall of an apple in the year 1665/6. Evidence of Newton's friendship with a prosperous Yorkshire family who planted an apple tree arbour in the early years of the eighteenth century to celebrate his discovery is presented. A considerable amount of new and unpublished pictorial and documentary material is included relating to a particular apple tree which grew in the garden of Woolsthorpe Manor (Newton's birthplace) and which blew down in a storm before the year 1816. Evidence is then presented which describes how this tree was chosen to be the focus of Newton's account. Details of the propagation of the apple tree growing in the garden at Woolsthorpe in the early part of the last century are then discussed, and the results of a dendrochronological study of two of these trees is presented. It is then pointed out that there is considerable evidence to show that the apple tree presently growing at Woolsthorpe and known as 'Newton's apple tree' is in fact the same specimen which was identified in the middle of the eighteenth century and which may now be 350 years old. In conclusion early results from a radiocarbon dating study being carried out at the University of Oxford on core samples from the Woolsthorpe tree lend support to the contention that the present tree is one and the same as that identified as Newton's apple tree more than 200 years ago. Very recently genetic fingerprinting techniques have been used in an attempt to identify from which sources the various 'Newton apple trees' planted throughout the world originate. The tentative result of this work suggests that there are two separate varieties of apple tree in existence which have been accepted as 'the tree'. One may conclude that at least some of the current Newton apple trees have no connection with the original tree at Woolsthorpe Manor.

Introduction

Who does not know the name of Newton is imperishable connected with an... apple? The story has been often repeated and often rejected. Those who are attached to it, however, will learn to their satisfaction that Professor Rigaud [Savillian Professor of Astronomy in the University of Oxford, 1827–1839] thinks it derived from unquestionable authority: and, moreover... the apple tree (now converted into a chair) is preserved at Woolsthorpe to testify to it to this day. (*The Edinburgh Review*, 1843: 419).

The story of Newton observing the fall of an apple and 'discovering the law of gravity' has been told to countless

generations and now has the status of a legend. When I first heard it I assumed that it was just an amusing anecdote. It was on a visit to Woolsthorpe Manor, in Lincolnshire, Newton's birthplace, in 1976 that I was surprised to learn that there was more to the story than I had realized. More surprising was the claim that a grafted cutting from the original apple tree was still growing in the garden. I recall looking at the small tree by the main door of the manor house with amazement and disbelief and wondering on what evidence this claim was based.

Over the years I have unearthed a considerable quantity of documentary evidence concerning the history of the story and the particular tree which has been quite taxing to come by. However there have been two instances which were completely unexpected, one of which brought forward a wealth of material without which this investigation would

have been stillborn. This occurred on a visit to the late Major H.B. Turnor in the spring of 1977, the last private owner of Woolsthorpe Manor. It transpired that the Turnor family had owned Woolsthorpe from the time of Newton and possessed records of the house from the early part of the eighteenth century. Amongst these was a drawing of 'the apple tree' taken 150 years earlier. After all the years of searching, this remains the most important single piece of evidence for there being a distinct, identifiable tree from which Newton observed the apple fall. The second occurred on a visit to Woolsthorpe Manor in September 1977 to photograph the house from the site of the original tree. I was walking backwards composing the scene from the Turnor drawing through the viewfinder of a camera when I found myself lying upon my back. Regaining my feet I looking round and was amazed to find that I had fallen over what appeared to be the tree illustrated in his drawing. Even now the memory of the event is disorientating for I recall the confusion of not knowing whether I was in the year 1820 or 1977. The surprise was compounded by the fact that on an earlier visit the warden of the property had not mentioned the existence of this ancient tree which was held by some to be a regeneration of Newton's original apple tree.

The sequence in which I shall present the facts of this investigation is anything but the order in which they have emerged. Firstly the accounts of the various versions of the story will be discussed in order to establish the historical background. It should be noted that some of this material has appeared in an article by McKie and de Beer [1], however it is necessary to recount it here for reference and completeness.

A brief note on the early life of Sir Isaac Newton

As so many of the events surrounding this investigation took place in and around Newton's home and not everyone will be familiar with the background to Newton's early life, I feel it is well to introduce a brief biographical sketch of the man to put the following narrative into context. Isaac Newton was born at Woolsthorpe Manor near Colsterworth some seven miles south of Grantham in Lincolnshire on Christmas day 1642. His parents had married in the previous April, however his father died suddenly in the September, some three months before his son and heir was born. Newton's mother, Hannah, was the daughter of a local clergyman, James Ayscough, and her brother William was also a local clergyman. Subsequently, Newton's uncle William was appointed to be his guardian until such time as he came of age and could manage his estate. And so it was that because of the circumstances of his birth, Newton owned Woolsthorpe Manor, for the whole of his life. If the trauma of his being born an orphan were not enough, his mother remarried before Isaac was three years old. He was left at Woolsthorpe in the care of his grandmother while his

own mother went to live with the Rev. Barnabus Smith at North Witham, a mile or so away. Smith was 63 years old and of some considerable means. Thus the young Newton was brought up without either parent until he was about 11 years old when his mother returned to the farm after the death of her second husband. By this time she had three more children with her, two girls and a boy.

Newton learned to read and write at two 'dame schools' in the area and at the age of 11 went to King's School in Grantham where he lodged with the local apothecary, a Mr Clark, during the week, returning home at the weekends. For the first three years at King's School, Newton was normally near the bottom of the class. It seemed that he was academically able, but his interests lay elsewhere. He, for instance, enjoyed making mechanical devices, sun dials, water clocks and the like and may have found regular school work dull. A much recorded incident was to change all this. It concerned a fight which Newton had with Richard Storer, the stepson of the apothecary Clark. There had been some disagreement between them and Storer had kicked Newton in the stomach. As a result Newton challenged him to a fight. After school they set about resolving their differences and Newton, the smaller boy, delivered such a beating to Storer that he pleaded for mercy, but Newton not yet satisfied, dragged the poor boy across to a wall and rubbed his nose into it. The dispute being settled Newton seemed to have resolved to overtake Storer in class and in doing so overtook the rest of the school. It soon became clear to his school master that they had in their midst a more than averagely capable young man. However at the age of 16 Newton's mother decided that he had had enough of education and he should start learning to look after his farm. This was a disastrous mistake, for not only was Isaac useless at managing a farm, he seems to have resented the interruption in his education, and his behaviour so antagonized his mother that after a year she gave up the unequal struggle and returned him to school, where he was to prepare for the university 'for he was unfit for anything else'!

Newton entered the University of Cambridge as a student of Trinity College on 5 July 1661. He was 18 years old. Possibly because of his mother's pique she would only provide him with an income of £10 per year and so he was forced to work as a college servant to pay his fees. In his third year he was relieved of this duty by being awarded a Trinity scholarship and he subsequently graduated in January 1665.

Whatever the intentions of his family, and it is thought that Newton was to study theology or law, he actually went to lectures by Isaac Barrow (the first Lucasian Professor of Mathematics) on optics and mastered the new subject of co-ordinate geometry, amongst other things. Over the next four years Newton became a junior fellow and then senior fellow of his college and in 1669 the Lucasian Professor of Mathematics. He was now 26 years old and had for several years been 'at the prime of his age for invention'.

It was in the summer of 1665 that the University sent its fellows back to their various homes because the plague was approaching the town. The university opened for a few months between March and June 1666, but otherwise Newton was away until April 1667. It was about this period that Newton gave the oft quoted account of his discoveries:

In the beginning of 1665 I found the Method of approximating series and the Rule for Reducing any dignity of any Binomial into such a series. The same year in May I found the method of Tangents of Gregory and Slusius, and in November had the direct method of fluxions and the next year in January had the Theory of Colours and in the May following I had entrance into ye inverse method of fluxions. And in the same year began to think of gravity extending to ye orb of the Moon and... I deduced the forces which keep the Planets in their Orbs must be reciprocally as the squares of their distances from the centres about which they revolve... All this was in the two plague years of 1665–6. For in those days I was in the prime of my age for invention and minded Mathematics and Philosophy more than at any time since [2].

Although this account comes from his old age Newton described, in a letter to Halley on 14 July 1686 [3] how he had shown, some 20 years earlier, that the force of gravity must fall off as the inverse square of the distance. This was from a consideration of Kepler's laws of planetary motion. As he already had the relation between centrifugal force and distance, it was a straightforward matter to calculate the orbital period of the Moon knowing its distance from the Earth and the terrestrial gravitational acceleration.

This is not the place to describe the many momentous events of Newton's academic life, however they culminated in his great work *Philosophiæ Naturalis Principia Mathematica* published in London in July 1686/7. This treatise which systematizes the mechanics of the universe is without doubt the greatest work of scientific genius that the world has yet seen. Newton left Cambridge in 1697 to become Master of the Mint. He was elected president of The Royal Society in 1703 and knighted by Queen Anne in 1705. He died in 1726, was given a 'state funeral' and his body was interred in Westminster Abbey.

After this detour I wish now to return to the central issue.

Accounts of the story which Newton told of his discovery of the law of universal gravitation

The first account to appear in print was published in 1727, the year of Newton's death, by Voltaire [4], it states:

Isaak Newton walking in his garden had the first Thought of his System of Gravitation, upon seeing an apple fall from a tree

This account seems to have been transmitted by Newton's niece, Catherine Barton, who for many years was his companion and housekeeper while he lived in London during the years 1697–1726. A second account was published in the same year coming from the Cambridge natural philosopher Robert Greene [5], and states (in translation from the Latin):

This was written by me when I reflected that Newton's theory of gravity is the beginning of everything... this celebrated theory has its origin like all our knowledge, it is said, from the apple. This I heard from the most learned and intelligent man... Martin Folkes esquire...

A further account appears in John Conduitt's collection for a biography of Sir Isaac Newton [6]. Conduitt married Newton's niece and was also his assistant at the Mint, becoming master upon the death of Newton in 1726. The account reads:

...and in the year 1665 when he retired to his own estate on account of the Plague, he first thought of his system of gravity which he hit upon by observing the fall of an apple from a tree.

The actual account in Conduitt's own hand appears in Figure 1. In an extended version [7] Conduitt states:

In the year 1666 he retired again from Cambridge... to his mother in Lincolnshire & while he was musing in a garden it came into his thought that the power of gravity (which brought an apple from a tree to the ground) was not limited to a certain distance from the earth, but that this power must extend much further than was usually thought. Why not as high as the Moon thought he to himself & that if so, that must influence her motion & perhaps retain her in her orbit, whereupon he fell a-calculating what would be the effect of that supposition but being absent from his books & taking the common estimate in use among Geographers and seamen before Norwood had measured the Earth, that 60 English miles were contained in one degree of latitude on the surface of the earth, his computation did not agree with his theory & inclined him to entertain a notion that together with the force of gravity there might be a mixture of that force which the Moon would have if it was carried along in a vortex...

Yet another version was given by William Stukeley who visited Sir Isaac Newton on 15 April 1725/6, as his diary records:

Ap.15. I din'd with him at his Lodgings alone, at Orbels buildings Kensington: His breakfast is of orange peel boiled in water...

Although the account of the incident of the apple does not appear in Stukeley's diary, it is recounted in his

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of any other person - In 1664 he
bought a prism to try some
experiments upon Des Cartes's ^{doctrine} ~~book~~
of colours & soon found out his
own ^{theory} hypothesis & the ~~errors~~ ^{errors} of
of Descartes's - About this time he
began to have the first hint of his
method of fluxions & in the year
1665 when he returned to his own
estate on account of the Plague
he discovered ^{his first thought of} his system of gravitation
which he felt to be ^{fit upon} by observing an
apple fall from a tree -
He ~~made~~ ^{made} all his discoveries before
he was 24 years old, & long before

Figure 1. An account of Newton's discovery of universal gravitation in John Conduitt's hand. Conduitt was Newton's assistant at the Royal Mint and married his niece Catherine Barton. (From the Portsmouth Manuscripts, Kings College Cambridge. Reproduced by kind permission of the Master and Fellows of King's College, Cambridge.)

biography of Newton which remained in manuscript form until the 1930's [8].

... After dinner, the weather being warm we went into the garden and drank tea, under the shade of some apple trees, only he and myself. Amidst other discourses, he told me that he was just in the same situation, as when formally the notion of gravity came into his mind. It was occasioned by the fall of an apple, as he sat in a contemplative mood.

A further reference to the story which has recently surfaced comes from Newton's friendship with William Dawson. As far as I am aware none of his biographers refers to this friendship or mention that Newton used on occasion to stay with the Damsons at Lancliffe Hall in North Yorkshire. William Dawson's entry in *Alumni Cantabrigiensis* (1922: 22) states:

Dawson William, adm. pens. (age 15) at Christ's Jan 28, 1691 – 2. S(on) of Christopher (1663) ...B.A. 1695–6 ... An able mathematician and classical scholar. A friend of Isaac Newton. Died June 25th 1762.

It is likely that William Dawson was taught by Isaac Newton in the last years of his residence at Cambridge. Further, in *The Craven and North-West Yorkshire Highlands*, by H. Speight, London (1892: 113–114) it is stated that:

William Dawson was a man of high classical learning and was one of the few people living at the time who could comprehend Isaac Newton's *Principia Philosophae*.

Speight continues:

The great philosopher is said to be an occasional visitor of Major Dawson at Lancliffe Hall, who had an arbour purposely constructed in the garden for him, wherein he is said to have passed many hours in solitary meditation... Before the rearrangement of the gardens and outbuildings there was a rookery and a small orchard at the north side of the house, where the kitchen garden now stands and two old apples yet remain. It is here where Newton's arbour stood, and the two fruit trees are credited with having sprung from an old tree planted by the Major to commemorate the philosopher's great discovery of the law of gravitation, from the well known story of his watching an apple fall while sitting alone in his home garden at Woolsthorpe, in Lincolnshire.

More weight is given to Newton's friendship with William Dawson when it is realized that his nephew, the Rev. Benjamin Smith, was rector of Linton in Wharfedale from 1733–1776. Whether or not Dawson had the account of the apple from Newton I have been unable to determine, however he planted an apple tree arbour to celebrate the account in the early years of the eighteenth century.

And so it was that Newton recounted the incident to many people. There can be little doubt that it was through the fall of an apple that Newton commenced his speculations upon the behaviour of gravity and that this occurred in the plague years 1665–6. I would emphasize John Conduitt's account and particularly the last sentence:

his computation did not agree with his theory and inclined him to entertain a notion that together with the force of gravity there might be a mixture of the force which the moon would have if it was carried along in a vortex...

Here the 'vortex' refers to Descartes's theory which attempted to explain planetary motion in terms of vortices in the aether. When Newton first estimated the orbital period of the Moon he found that his calculations were in

considerable error. At the time, he seems to have been unaware that this error lay in an underestimate of the Earth–Moon distance and consequently concluded that vortices could play a part in controlling the moon's motion. This could then explain why Newton left the subject for so long before taking it up again in the *Principia*. It should be noted that an accurate value of the Earth–Moon distance had been known since Richard Norwood surveyed the London–York road between 1633 and 1635 and determined the number of miles per degree to be 69.5. This result was published in *A Sea-Mans Practice* (London, 1637).

The ownership of Woolsthorpe Manor (Newton's birthplace)

The fact that there exists documentary evidence relating to a particular apple tree associated with Newton's discovery of universal gravitation is to a large extent due to the continuity of ownership of Woolsthorpe Manor by the Turnor's of Stoke Rochford from the time of Newton to the present day. After Isaac Newton's death in 1726 the farm passed to his heir-at-law one John Newton. In 1732 John Newton sold it to Thomas Alcock who then disposed of it to Edmund Turnor in 1733. The ownership of Woolsthorpe Manor stayed in the Turnor family for 210 years through the following line:

Edmund Turnor (1688–1769): purchased in 1733, aged 45
 Edmund Turnor (1715–1805): succeeded in 1769, aged 54
 Edmund Turnor FRS (1754–1829): succeeded in 1805, aged 51
 Christopher Turnor (1809–1886): succeeded in 1829, aged 20
 Christopher Turnor (1873–1940): succeeded in 1886, aged 13
 Herbert Turnor (1886–1980): succeeded in 1940, aged 54.

Woolsthorpe Manor is now owned in perpetuity by the National Trust. The Turnors were a wealthy Lincolnshire family who bought the farm to increase their holding of land; they never lived in the house, but let it to the Woollerton family who lived there during most of the period of the Turnor ownership. There was thus continuity of ownership and occupation from a mere six years after Newton's death to the present day. I first met Major Herbert Turnor in March 1977 and had a lengthy correspondence with him, and it is from him that important elements of this account come. Further I have been fortunate to have been able to discuss the history of the Woollerton family's involvement with the last person to have been born there, Ms Marion Woollerton, who has been of considerable assistance.

The specific apple tree at Woolsthorpe Manor

The first mention of a specific apple tree associated with Newton's own account of his speculations upon the nature

of universal gravitation appears in the book *Collections for the History of the Town and Soak of Grantham*, by Edmund Turnor FRS (1754–1829) published in 1806. A footnote on page 160 states that:

The apple tree is now remaining and is showed to strangers.

This is 80 years after Newton's death. The tone of the statement is purely factual, and one concludes that Edmund Turnor accepted the tree as the one from which the famous apple fell, for it had been growing on what was one of the family farms from a time long before his birth. This view is supported by the account of the tree which accompanies a small log in the possession of the Royal Astronomical Society in London, from a Mr Walker, dated 12 January 1912:

The little log of wood I am sending to the Secretary of the Royal Astronomical Society, is a piece of an apple tree at Woolsthorpe, the home of Sir Isaac Newton... The history of this piece of wood, and the way in which I came to have it, is as follows: My father Richard Walker, was born at Bradmore, Nottinghamshire, at the Manor Farm there in 1807. He went to school, when he was 10 or 12 years of age, to the clergyman of Stoke, Lincolnshire, named Pearson. [Author's note: it turned out that Pearson was not the clergyman but his curate, as the Bishop's Visitation in Lincoln County Records Office show]. My father told me that while he was at school there, there was a very severe storm of wind one night, and that in the morning news came that Sir Isaac Newton's apple tree had blown down at Woolsthorpe. The school master, Mr Pearson and several of the boys at once set off for Woolsthorpe, where Sir Isaac Newton's home was, and which is not far from Stoke, and just on the Lincolnshire side of Belvoir Castle. When they arrived there they saw the old apple tree lying on the ground. It had been propped up all round for many years, and every effort had been made to preserve it. My father said it lay there, having by the force of the wind, blown over its props. He said that he did not know by what authority Mr Pearson acted, but that he obtained a saw from somewhere and sawed a good many logs of wood from the branches. My father got one of these pieces, which he always kept as being a most interesting relic. Various friends and other people often tried to induce my father to part with it, but he always refused, as he prized it very much indeed.

My father often showed the piece of wood to me, repeating the circumstances under which he got it. There cannot be the least doubt of its coming into his possession in the way I have said.

From the description of the tree's being propped up for many years, and every effort being made to preserve it, one must conclude that the tradition of the tree was very well established by the latter part of the eighteenth century.

where Newton used to sit in full view of the single apple tree in the garden. My father's holographic statement goes on to say that Sir David cut this piece of the remains and presented it to him (J.D.F.) very shortly afterwards. The dates are given in the corner of the document written by my father, there is a sketch (copied from Sir David Brewster's) or plan of the house and little garden, with the site of the apple tree root marked by a circle.

The map which was at one time in the box is now missing; however George Forbes states in a footnote on page 52 of his book, *History of Astronomy*, (London, 1921):

The writer inherited from his father (Professor J.D. Forbes) a small box containing a bit of wood and a slip of paper, which had been presented to him by Sir David Brewster. On this paper Sir David had written these words: 'If there be any truth in the story that Newton was led to the theory of gravitation by the fall of an apple, this bit of wood is probably a piece of the tree from which Newton saw the apple fall. When I was on a pilgrimage to the house in which Newton was born, I cut it off an ancient apple tree growing in the garden.'

Thus, although the apple tree blew down in a gale some time between 1817 and 1820 parts of the tree were still there in 1830, when Brewster cut pieces from its root. At the present

time neither the whereabouts of the map made by Brewster nor the copy drawn by J.D. Forbes is known to me, however we do now know what Brewster wrote on the map. I have searched diligently for these maps! (See note 1, Appendix).

A further account of the apple tree has recently come to light through the purchase of a small circular lignum vitae box by the Museum of the Royal Mint. The box contains a wax portrait bust of Newton and a drawing of Woolsthorpe Manor together with a hand written inscription which contains the facts of Newton's life and his discovery of universal gravitation through the fall of an apple. It is dated 1835 but essentially repeats that which has already been stated.

The pictorial evidence of the apple tree

A drawing of the apple tree and its position in relation to the manor house dated 1820 was made by the Rev. Charles Turnor (1763–1853), Edmund (1754–1829) Turnor's brother. The caption on the drawing reads:

Woolsthorpe Manor House 1820 C.J. Turnor The Famous Apple Tree

which is reproduced in figure 3.



Figure 3. Newton's apple tree in the garden of Woolsthorpe Manor, drawn by the Rev. Charles Turnor in 1820. The 'fan shaped' protrusion represents the broken trunk of the tree which can be seen in figure 4. (Private collection.)

The earliest picture of the apple tree yet to come to light dates from 1816 and is reproduced as figure 4. It shows the apple tree from a position facing in a direction parallel to the Manor House. The inscription appended to it reads:

A copy made from a drawing made in the year 1816 of a decayed apple tree situated in an orchard adjoining the manor house at Woolsthorpe, a hamlet of Colsterworth, once the property of the Newtons, but now in the possession of Edmund Turnor Esq and is supposed to be the same tree from which Sir Isaac Newton beheld the fall of an apple which suggested to the mind of that great man the doctrine of gravity.

From figure 3 it can be seen that the strange 'fan like' protrusion which appears at the back of the vertical branch in Charles Turnor's drawing is in fact the broken trunk of the tree lying on the ground. It is clear from these two drawings that the tree had already blown down

before 1820 and it seems to have established itself in this position. The canopy at the top of the vertical branch is growing and would have taken some time to have established itself. Although Charles Turnor was not a trained artist, we shall see later that there is good reason to believe that this drawing is a factual representation of what he observed. In comparing the two drawings it will be noticed that the end of the prone trunk in figure 4 has been sawn off cleanly. From the fact that there are two canopies being supported by the broken trunk, it is evident that the tree was obtaining sufficient nutrients to support them.

A third drawing, of unknown date, appears in Charles Turnor's *Newtoniana* Vol. 1, p.122, The Royal Society, London. On the reverse of the drawing is the inscription:

N-W view of the manor house at Woolsthorpe drawn by G.Rowe, Chillingham from the original picture in my possession by Thos Harrison.



Figure 4. Newton's apple tree as it appeared in 1816, taken from a position at right angles to the view in figure 3. (Reproduced by permission of The Royal Society, London.)

Limitations on space does not permit a reproduction of this drawing however it contains some artistic licence, for the house appears to stand on level ground but in fact the site slopes quite markedly. Apart from this it is clear that the apple tree is the one illustrated in figures 3 and 4 and is shown bearing two large canopies of leaves. The whereabouts of the original painting is at present unknown.

These are the earliest pictures of the apple tree of which I know, however it is likely that several others exist for in the early 1820s many artists visited Woolsthorpe and made drawings of the house. The signatures of some of these artists appear in the first volume of the visitors book which was kept from 1820 to 1943. (see Appendix)

And so it was that by the early part of the eighteenth century the account of Newton's discovery of universal

gravitation was in print and by the end of the century an ancient and venerated apple tree had been identified as growing in the garden of Woolsthorpe Manor. The obvious question is why this tree should have been chosen to be the subject of the account, for nowhere in any of the early versions is a particular tree mentioned. It is due to Professor John Robison (1739–1805, Professor of Natural Philosophy in the University of Edinburgh) that a clue to the answer to this question exists. Robison was collecting material for a biography of Newton and commissioned the artist J.C. Barrow (fl.1782–1802) to make a series of drawings of Woolsthorpe Manor. At least nine were made on 3 and 4 August 1797. I first saw two of these as watercolours in the Grantham Public Library and Museum. They were removed from their frames for photographing and were examined to discover what if anything was written on their reverse sides. The contents of these frames was totally unexpected.

Between the watercolour and backing board of one of the drawings was an accurate plan of the house and surrounding lands, figure 5, and appended to the map was the following statement:

This is one of four views of the house in which Sir Isaac Newton was born. They were taken by Mr J.C. Barrow, an artist, by desire of Mr Robison who visited Colsterworth in the course of a journey to London in the year 1796 to attend as a witness for Mr. Watt's patent for the steam engine. I have thought it right to give this explanation as I accompanied Mr Robison on that occasion and am personally acquainted with the history of these drawings. These two framed by R. Robison 1814.

The inscription is signed by Rachael Wright Robison, the wife of John. In order to indicate the precise detail and historical significance of Barrow's watercolours I thought it important to reproduce the north west view in figure 6, which can be seen to have been taken from the observation points OB.

There are several points to note about this map. Of prime importance is the position of the orchard; it is the walled enclosure lying to the north of the manor house, and there is an entrance to it just to the east of the kitchen garden. The second point to note is that Barrow has not shown the 'garden' to the house on his map. The garden can, however, be seen in the view of the house from the observation point OB (figure 6) and was, in 1797, separated from the house by a hedge.

The Barrow watercolours relate to a period 130 years after the incident of the apple, and it could be argued that considerable changes may have taken place to the house and its environs over such a long period of time. The fact that this was not the case is shown in the following drawing. William Stukeley (1687–1765), anti-

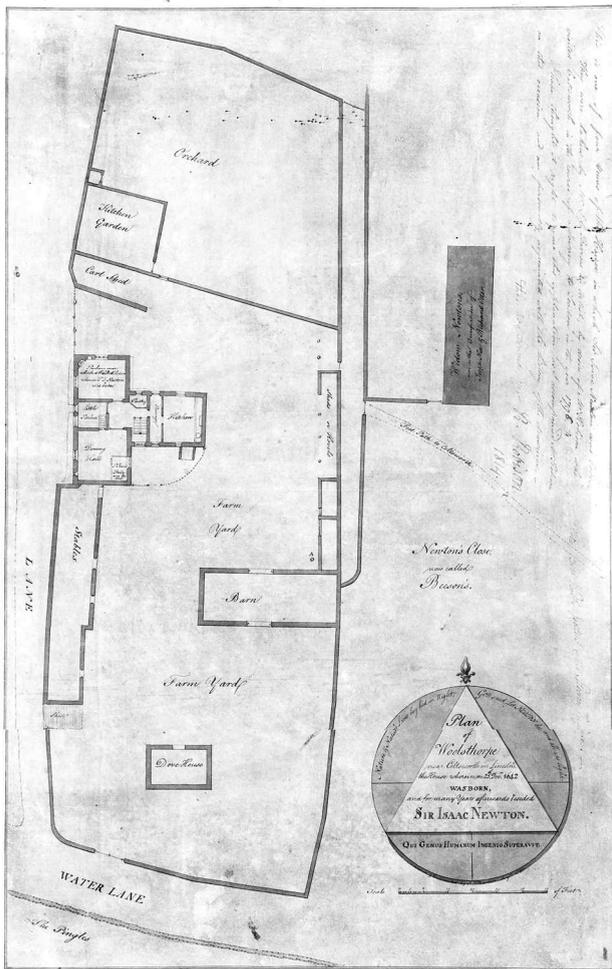


Figure 5. A detailed site plan of Woolsthorpe Manor drawn by J.C. Barrow in August 1797, showing the position of the manor house, orchard and farmyard. The garden of the house is off the bottom of the plan across a little lane. (Reproduced by permission of Lincolnshire County Council and Grantham Museum.)



Figure 6. The northwest view of Woolsthorpe Manor, August 1797 by J.C. Barrow. On the right of the picture can be seen the hedge which at this time divided the house from its garden. (Reproduced by permission of Lincolnshire County Council and Grantham Museum.)

quarian, doctor of medicine and friend of Newton visited Woolsthorpe Manor early in the eighteenth century in the course of collecting material for a biography of Newton, and made the sketch of the house shown in figure 7. Although the drawing is somewhat crude, the house is perfectly recognizable, as is the door into what we now recognize as the orchard. There thus appears to be little alteration to the layout of the garden, orchard and farmyard from 1720 to the end of the eighteenth century.

Returning to the contents of the Barrow water colours at Grantham, the second one contained a detailed floor plan of the house and an engraving of the manor dated 1772. The engraving is accurate but fails to show the site of 'the tree'. One might have expected Tinkler, the artist, to have included it in his composition, as Newton's account had been in print for 50 years, and it seems that the tree was being cherished by this time. The tree does not appear in Stukeley's drawing either and he obtained the account directly from Newton. This drawing dates from the 13 October 1721 (see the letter to Dr Mead in 1727, and discussed in *The Saturday Magazine*, 1824, p.13), and Stukeley may not have been aware of the story till five years after this visit which could explain the omission. I must admit to a certain amount of 'ingenuity' in this explanation, for there is no evidence that Newton ever identified a tree himself; the tree was I believe chosen by force of circumstance.

The inscription on the Barrow plan states that there are four drawings of the house. The two in Grantham Art Gallery and Museum are from opposite compass points, and it may well be that the missing two were taken from the other two compass points. If this were the case then one of them would be expected to show an accurate view of the

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1665 and 1666 were years of Plague, and Newton spent the times when the University was closed at home.
Woolsthorpe Manor. An early 18th-century sketch by William Stukeley of Newton's mother's house.

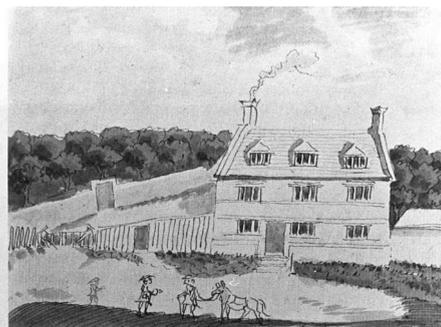


Figure 7. Woolsthorpe Manor drawn by William Stukeley on 13 August 1721. The gate into the orchard can be seen on the left of the drawing.

apple tree propped up as Walker described in his letter to the Royal Astronomical Society.

At this point my enquiries were directed to Mr R.N Smart, archivist at The University of St Andrews. It soon transpired that some of the Barrow drawings were mentioned in Robison's will. Three of them were framed in a single oak frame, and they were given to Professor J.D. Forbes by Sir John Robison (Professor John Robison's son). After a protracted search, these drawings turned up in the Royal Scottish Museum in Edinburgh. It turned out, to my considerable frustration, that two of the drawings were the original measure drawings from which the Grantham watercolours were taken. The northwest view is numbered 4 and the southeast view 3. The third drawing was of the interior of the bedroom in which Newton was born and appears to be unnumbered. Where were the other drawings mentioned by Mrs Robison?

Eventually four more of the Barrow series of drawings came to light in Prof. J.D. Forbes' scrap book at the University of St Andrews. The only exterior view was a distant prospect of the manor house and farm buildings from the southeast. The three interior views were of the kitchen and main staircase in the manor and a zig-zag brick arch which is in an ancient cottage nearby. Three of the drawings are numbered, the highest being 9. Thus there were at least nine drawings in the series and only seven are as yet known to me. It is beyond credulity that J.C. Barrow would have done such an extensive series of drawings without including the, by then famous, apple tree. However if it still exists, it has eluded me.

Returning to the Barrow map (figure 5), it will be seen that the garden, which by 1797 was hedged, was separated from the house by a little lane. In Newton's day however there was no dividing hedge, as can be seen in the sketch of Stukeley (figure 7). Thus, apart from the presence of the hedge, the house and grounds which Barrow documented were much the same as in Newton's day. Many more prints

and drawings of the house exist and several discuss the presence of the apple tree, however they do not materially alter the picture which I have given.

The identification of a particular apple tree at Woolsthorpe

As far as I have been able to discover no account of the apple tree story from the early part of the eighteenth century associates a particular tree with the incident. However there is no doubt that within possibly 50 years of Newton's death, an apple tree was being cherished as 'the tree from which the apple fell'. The pressing question is why any particular tree should be associated with Newton's account. The answer to this turns out to be remarkably simple. As the account describes Newton sitting in his garden when the incident occurred, the tree from which the apple fell selected itself because it was the only apple tree growing in his garden. Newton's garden was totally distinct from his orchard and the rest of the property, as we have seen. Had the account said that the incident occurred in his orchard, then it would have been impossible to associate the story with any specific tree.

The fact that the apple tree was the only one growing in Newton's garden is mentioned by Professor George Forbes in his note to the The Royal Society, and it appears that the account came from Brewster. Thus if the original account is correct, and Newton did see an apple fall from a tree in 'his garden', the ancient tree which Charles Turnor drew, and which had been cherished for generations as the actual tree, was most probably chosen because it was the sole candidate for the role.

The propagation of the apple tree in the nineteenth century

Beneath a copy of a drawing/lithograph of the fallen apple tree now in the possession of The Royal Society (Figure 4) which appears in Volume I of Charles Turnor's six volume work, *Newtoniana*, is the following inscription:

NEWTON'S APPLE TREE AS IT WAS IN 1840

On its reverse is the following statement:

The celebrated apple tree in the garden of Woolsthorpe Manor drawn by F. Howison in 1840 from a lithograph sketched about the year 1820. I had some grafts taken from this tree which was then much decayed, and there are now (1840) two thriving apple trees growing from it. One is in the orchard of George Carrington Esq. of Missenden Abbey, Bucks, and the other is in the garden of Mr. George Dodd, paper maker, at Cheneys in the said county
C.T. June 1840

This is the only contemporary record I have managed to trace of the propagation of Newton's apple tree. It is of

considerable concern to me that several generations after these trees were propagated they were cut down because of ignorance of what they were.

Although there appear to be no contemporary records of the propagation of Newton's apple tree in the records of Lord Brownlow at Belton Park, there is evidence that the tree was propagated there early in the last century. Belton Park lies about six miles northeast of Grantham and the Turnors and Brownlows were neighbours. This came to light when Sir Stephen Tallents considered establishing a garden of historical plants in 1937 [9]. During a conversation between Christopher Turnor (the then owner of Woolsthorpe Manor), and Sir Stephen Tallents at Broadcasting House in 1939, the existence of a scion of Newton's apple tree growing at Belton Park was mentioned. Subsequently a scion of this tree was grafted at the Fruit Research Station at East Malling and it is from this material that most of the Newton apple trees planted worldwide come.

Some doubt was expressed in the early 1950s that the two sources of Newton's apple tree were in fact the same variety. However subsequent comparisons of the wood, foliage and fruit of the two trees showed them both to be the same rare variety, *Flower* (or *Pride*) of *Kent*. An early mention of this variety appears in John Parkinson's, *Paradesus* (1629). Today the variety *Flower of Kent* is very uncommon and only about one in 300 samples of apple sent for identification to the Fruit Research Centre at East Malling turn out to be of this variety. Thus, although there is no documentary evidence to show that the propagation from Woolsthorpe to Belton took place, the fact that they are of the same rare variety lends support to the account. However, see later!

The Newton apple tree at Woolsthorpe Manor

The apple tree over which I tumbled in September 1977 is shown in a recent photograph in figure 8 from approximately the same position as Charles Turnor made his drawing in 1820 (figure 3). The barn which used to be attached to the house was removed after the last war but apart from this the scene is much the same as it was 178 years earlier. From the Turnor drawing and the 1816 lithograph (figure 4) it will be observed that the root of the tree originally grew about 8 feet nearer the line of the buildings. If the tree illustrated in figures 3 and 4 is the one from which Newton saw the apple fall, one might assume that it was planted about the year 1650; it would then have grown for about 170 years before it blew down. Comparing the Turnor drawing and the 1816 lithograph confirms that the tree was supporting two leaf canopies and that it must then have been receiving sufficient nutrients through its broken trunk to support this growth. Several accounts state that the original apple tree at

Woolsthorpe was cut down and Mr Turnor had it made into a chair (see figure 9). Charles Turnor's drawing which appears in *Newtoniana* (Vol.1) is a good likeness of the actual chair in the modern photograph and thus there is every reason to believe that his drawing of the apple tree and manor house (figure 4) is similarly accurate. From Walker's statement we know that the tree blew down sometime before 1820. However the root of the tree was not removed, for Brewster took samples in 1830 and Charles Turnor described the tree as still standing in 1840. It must be pointed out that although Charles Turnor describes 'Newton's apple tree as it was in 1840' the drawing is the one of 1816 and he may have meant that the copy was made in 1840.



Figure 8. A photograph of the apple tree and the manor house taken on the 21 March 1998 from approximately the same position as Charles Turnor made his drawing in 1820 (figure 3.)

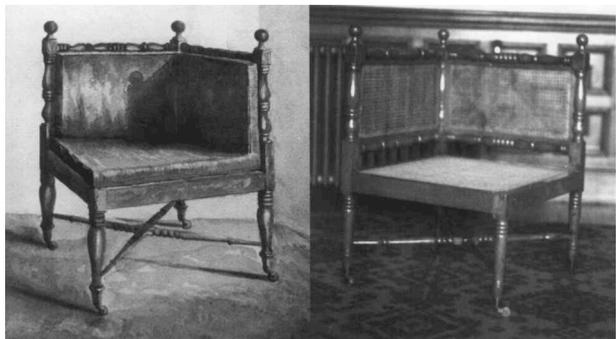


Figure 9. Charles Turnor's watercolour of the chair made from some of the wood from Newton's apple tree, and a modern photograph of the chair. The watercolour is reproduced by permission of The Royal Society, London. The chair was at Stoke Rochford Hall when photographed in 1977, but is now in a private collection.

Comparing the photograph taken in 1998 (figure 8) with the Turnor drawing (figure 3) it can be seen that the two trees are growing in approximately the same position. There is also a remarkable similarity between their modes of growth and orientation. The present trunk lies along the ground for about 8 feet, has rooted at both ends and appears to lie on the same line as did the large prone branch of the tree shown in Turnor's drawing. I suggest that between 1840 and the 1930s the tree was allowed to grow unmolested to become that which is shown in the photograph taken sometime between 1927 and 1940 (figure 10). The tree had undergone some surgery by 1978, (figure 11) when dendrochronological samples were taken and considerably more surgery was undertaken by 1998.

Comparing my photograph of March 1978 (figure 11) with Turnor's drawing it seems possible that the small branch at the lefthand end of the trunk and the little twig to its right, grew into the two major ascending branches. The left hand one was removed by the National Trust sometime within the last 15 years. The large rising branch in Turnor's drawing no longer exists and it may be that it was to its removal that the early accounts of the taking down of the tree refers (see note 2).

Whether this is the tree shown in the Turnor drawing or not remains to be seen, however it was thought important enough by the then director of Kew Gardens to send a member of his staff to collect cuttings from it in 1942. These were grafted and sent to the USA in the following year (at the height of the Second World War) and it is from this material that several of the Newton apple trees currently growing in the USA come.

If the Turnor tree and the one in figure 11 are one and the same then the ascending branches must have been about 160 years old (in 1977). The question arises; is Newton's original apple tree still growing today?



Figure 10. Newton's apple tree as it appeared sometime between 1927 and 1940 with Woolsthorpe Manor in the background. (Private collection.)

In an attempt to resolve this question it was decided to try and date the tree using dendrochronology.

A dendrochronological investigation of the trees at Woolsthorpe Manor and Belton Park

Permission was granted by the National Trust for core samples to be taken, from the positions shown in figure 11 : the work being done on 3 March 1978. This was carried out by Dr Malcolm Hughes, currently head of the Department of Dendrochronology at the University of Arizona.

The Woolsthorpe Tree

The core taken from position D showed the trunk to be hollow and little information could be obtained from it. Core F has a series of 15 widely spaced bands occupying about 60 mm, some 40 further bands which occupy 10 mm and then a region of undifferentiated material. A simple ring count would indicate that in 1978 the core of this branch was about 55 years old. One would then conclude that it started growing in 1923 . However comparison of the photograph taken sometime between 1927 and 1940 (figure 10) with that of 1977 (figure 11) shows there to be no significant difference in the appearance in the main rising branch over this period. Thus one is left to conclude that either the tree grew to its present size over a maximum period of 17 years (1927 – 1940) putting on 55 rings and then ceased growing altogether, or a simple ring count gives no indication of its age. Further comparison of the bases of the rising branches in the two photographs indicates that the tree has wasted slightly, rather than growing, over the last 40 or 50 years. It should also be pointed out that Miss Marion Woollerton, the last person to be born at Woolsthorpe Manor, remembers this tree when she was a child before the First World War.

The Belton Park Tree

Permission was obtained from Lord Brownlow to take core samples from the tree at Belton Park and this work was carried out on the same day as that done at Woolsthorpe. Very similar results were obtained. A period of rapid growth was followed by a period of very slow growth and then material with undetectable differentiation occurred. We have no supporting documentary material for this tree and thus nothing of significance can be deduced. What is apparent from this study is that, without further research, apple is not a good subject for dendrochronology. Once again, lack of space precludes my being able to include a photograph of this tree, however those who are interested will find it growing in an old orchard outside the kitchen garden in a position 33 feet from the Manthorpe – Belton boundary wall and 53 feet back from the corner of the wall of the kitchen garden.

Radiocarbon dating

There is a further avenue open which would, in principal, allow the age of these trees to be determined, that of radiocarbon dating. Accelerator mass spectrometer (AMS) radiocarbon dating requires only mg samples of material and taking a correlated ring set from the wood adjacent to the core of the tree could lead to a dating accuracy considerably better than ± 25 years. This work is technically complex, time consuming and expensive to perform, however, and due in large measure to the good offices of Gwen Singleton and Ian Fell of the Educational Division of Yorkshire Television, this work has commenced at the Research Laboratory for Archaeology at the University of Oxford, where core F, from the rising branch of the tree at Woolsthorpe shown in figure 11, was under investigation by 1995. Application of the technique to dating material which may only be 170 years old relies heavily upon its coming from a period where there was significant temporal variation of the carbon 14 composition in the atmosphere. A 'window of opportunity' exists between 1790 and 1810 but dating at times later than 1820 becomes much more difficult. The work, although currently in abeyance, took three samples from core F and indicated that the centre material originated from around the years 1810 to 1820.

In so far as this result stands further investigation, it lends support to the contention that the tree now growing at Woolsthorpe Manor and known as Newton's apple tree is one and the same tree which Edmund Turner described in 1806 and was drawn by his brother Charles in 1820. Thus, although the tree blew down in a storm before the year 1820 and some of it was made into a chair, it appears that the prone trunk was left to re-root where it fell, for as I have pointed out earlier, material was collected from it by Brewster in 1830.



Figure 11. Newton's apple tree at Woolsthorpe, showing the positions from which core samples were taken on the 13 March 1978.

Genetic fingerprinting

Recently work has commenced to genetically fingerprint the many Newton apple trees which have been planted in the US and the UK since 1943 (see *New Scientist*, 6 September 1997). Although the work is at a preliminary stage it has already been discovered that the doubts which were expressed in the 1950s may have been well founded. Although the various specimens of the tree look superficially very similar there seems to be two separate varieties of apple tree currently being propagated as 'Newton's apple'. It has yet to be confirmed whether these relate uniquely to the Woolsthorpe or to the Belton tree. Even more recently it has been suggested that it may be possible to extract DNA from the 'Walker log' at the RAS which could then show which if either of the trees which are used for propagation is related to the original tree in Turnor's drawing of 1820. At present, although attempts have been made to extract DNA from dead wood, these have been unsuccessful. This is an interesting area of research and more work is needed to establish whether or not DNA extraction is possible.

Comments, summary and conclusions

Over the years, several authors have expressed doubt concerning the veracity of the account which Newton gave of his discovery of universal gravitation. Whiteside [10] claims that as Newton's original calculation from 1665/6 has not come to light the account which Newton gave 'must be demoted to mere unsupported anecdote'. With the wealth of documentary evidence which exists of Newton's own account of his discovery of universal gravitation it appears to me that Whiteside's position is, to say the least, somewhat extreme. For my part, I am content to accept Newton's account, for it seems unlikely to me that a man who was acknowledged to be the greatest mathematician and scientist of his age, and who stood in the deepest awe of the judgement of God would put his immortal soul in jeopardy by fabricating such an unnecessary falsehood.

Considerable direct and indirect evidence sets the place of the incident as his garden at Woolsthorpe Manor. There is no evidence to suggest that Newton identified a particular apple tree, however within possibly a few decades of his death a tree had been associated with the account and was being cherished as 'the apple tree'. The reason for this appears simply to have been that the apple tree was the only one in his garden. By the year 1806, when it was first mentioned by Edmund Turnor, the tree would have been about 150 years old, and within the next decade had been blown down in a gale. By this time it had been propagated to several sites. Although it is stated by George Forbes, that the tree was removed by its owners, the existing evidence indicates that only part of the tree was removed to be made

into a chair. This we know from Brewster's cutting material from its root in 1830. Further in the opening quotation from Rigaud he points out that the chair made from some of the wood was then at Woolsthorpe in 1843. It seems unlikely that the tree which had been growing in a prone position for 25 years could have been taken down, sawn up, seasoned and made into a chair all in the space of a couple of years. With these facts in mind I would like to suggest that the prone hollow trunk which is rooted at each end and is today still growing at Woolsthorpe Manor is the prone branch of the tree drawn by Charles Turnor in 1820, and is one and the same tree which was identified as the tree from which Newton saw an apple fall in the year 1665/6. If this is the case, the apple tree must now be about 350 years old.

Acknowledgements

I wish to acknowledge the debt of gratitude which I owe to the late Major H.B. Turnor, without who's assistance and encouragement the investigation would have been stillborn. I am also indebted to the late Professor Sir Edward Bullard FRS for his considerable assistance with the investigation. He spent some time investigating the story and was responsible for planting a Newton apple tree at the National Physical Laboratory in Teddington when he was the director. Mr R.N. Smart of the University of St Andrews was of great help in tracing the Forbes material. Further I wish to thank Mr L.P. Townsend, one time archivist at the Royal Society, for his work in tracing material in their possession. Ms Marion Woollerton has also been of considerable assistance in providing information concerning her family's connection with Woolsthorpe Manor. I am also indebted to the staff at the Grantham Public Library and Art Gallery, and the staff at the Royal Scottish Museum in Edinburgh for help with the Barrow drawings. Although I have only made passing reference to the Fruit Research Station at East Malling in Kent, I have received considerable help throughout the investigation. My brother J.S. Keesing at the Royal Botanical Gardens at Kew and staff at the botanical gardens in Cambridge have also been of considerable assistance.

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Finally I wish to thank Dr E.D. Lyman and the late Professor J.O. Young and the many staff at the University of Nebraska who invited me to go out and describe the results of this investigation, for without this stimulus the material may never have been put together in a recognizable form.

Appendix

The Woolsthorpe Manor visitors book

Visitors books were kept at Woolsthorpe manor by the Woolerton family from 1820 to 1943, and the three volumes are presently in their possession. Several years ago a microfilm copy was made which I still have. It contains some 4000 signatures, the most famous of which is that of A. Einstein of Berlin who visited the house on the 6th June 1930. The names of some of the artists (and dates of their visits) who are referred to in the text and who may have recorded the tree are: Benjamin Johnson (18 March 1822); George Shepherd (28 August 1822); George Long, J. Kilvington and John Hart (3 October 1822).

Notes

1. The two copies of the Woolsthorpe maps mentioned by George Forbes: the original Brewster map is thought to have been lost in the disastrous fire at the Brewster–McPhearson's home in 1909. The J.D. Forbes copy was in the archives of the Royal Society until the last war when the material was dispersed for 'safe keeping' and possibly not returned.
2. Very recently I was informed by Professor Robert Reid (Emeritus Professor of Chemistry at MIT) that on a visit to Belton Park to take samples from the Newton apple tree for genetic fingerprinting, he was told that it had been destroyed because it had canker. Several months later I visited Belton to make enquiries about the incident and was shown the tree standing where I had photographed it 20 years earlier. What in fact had happened was that a branch had been removed to control the canker but otherwise the tree was unharmed!

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R.G. Keesing is a lecturer in the Department of Physics at the University of York and has had an abiding interest in the history and philosophy of science for most of his life. His early experimental research was in high energy resolution electron–atom scattering; however he became interested in the fundamentals of the photoemission process and carried out research into quantum tunnelling through atomically clean surfaces upon which atom layers had been deposited. This was in an attempt to discover how significant the process of 'electron blooming' could be in practice. He is currently investigating the phenomenon of 'single bubble sonoluminescence' to discover what part, if any, the quantum vacuum plays in the emission of the radiation.