Sir Isaac Newton

Born: 4 Jan 1643 in Woolsthorpe, Lincolnshire, England
Died: 31 March 1727 in London, England

Isaac Newton's life can be divided into three quite distinct periods. The first is his boyhood days from 1643 up to his appointment to a chair in 1669. The second period from 1669 to 1687 was the highly productive period in which he was Lucasian professor at Cambridge. The third period (nearly as long as the other two combined) saw Newton as a highly paid government official in London with little further interest in mathematical research.

Isaac Newton was born in the manor house of Woolsthorpe, near Grantham in Lincolnshire. Although by the calendar in use at the time of his birth he was born on Christmas Day 1642, we give the date of 4 January 1643 in this biography which is the "corrected" Gregorian calendar date bringing it into line with our present calendar. (The Gregorian calendar was not adopted in England until 1752.) Isaac Newton came from a family of farmers but never knew his father, also named Isaac Newton, who died in October 1642, three months before his son was born. Although Isaac's father owned property and animals which made him quite a wealthy man, he was completely uneducated and could not sign his own name.

Isaac's mother Hannah Ayscough remarried Barnabas Smith the minister of the church at North Witham, a nearby village, when Isaac was two years old. The young child was then left in the care of his grandmother Margery Ayscough at Woolsthorpe. Basically treated as an orphan, Isaac did not have a happy childhood. His grandfather James Ayscough was never mentioned by Isaac in later life and the fact that James left nothing to Isaac in his will, made when the boy was ten years old, suggests that there was no love lost between the two. There is no doubt that Isaac felt very bitter towards his mother and his step-father Barnabas Smith. When examining his sins at age nineteen, Isaac listed:-

Threatening my father and mother Smith to burn them and the house over them.

Upon the death of his stepfather in 1653, Newton lived in an extended family consisting of his mother, his grandmother, one half-brother, and two half-sisters. From shortly after this time Isaac began attending the Free Grammar School in Grantham. Although this was only five miles from his home, Isaac lodged with the Clark family at Grantham. However he seems to have shown little promise in academic work. His school reports described him as 'idle' and 'inattentive'. His mother, by now a lady of reasonable wealth and property, thought that her eldest son was the right person to manage her affairs and her estate. Isaac was taken away from school but soon showed that he had no talent, or interest, in managing an estate.

An uncle, William Ayscough, decided that Isaac should prepare for entering university and, having persuaded his mother that this was the right thing to do, Isaac was allowed to return to the Free Grammar School in Grantham in 1660 to complete his school education. This time he lodged with Stokes, who was the headmaster of the school, and it would appear that, despite suggestions that he had previously shown no academic promise, Isaac must have convinced some of those around him that he had academic promise. Some evidence points to Stokes also persuading Isaac's mother to let him enter university, so it is likely that Isaac had shown more promise in his first spell at the school than the school reports suggest. Another piece of evidence comes from Isaac's list of sins referred to above. He lists one of his sins as:-

... setting my heart on money, learning, and pleasure more than Thee ...

which tells us that Isaac must have had a passion for learning.

We know nothing about what Isaac learnt in preparation for university, but Stokes was an able man and almost certainly gave Isaac private coaching and a good grounding. There is no evidence that he learnt any mathematics, but we cannot rule out Stokes introducing him to Euclid's *Elements* which he was well capable of teaching (although there is evidence mentioned below that Newton did not read Euclid before 1663). Anecdotes abound about a mechanical ability which Isaac displayed at the school and stories are told of his skill in making models of machines, in particular of clocks and windmills. However, when biographers seek information about famous people there is always a tendency for people to report what they think is expected of them, and these anecdotes may simply be made up later by those who felt that the most famous scientist in the world ought to have had these skills at school.

Newton entered his uncle's old College, Trinity College Cambridge, on 5 June 1661. He was older than most of his fellow students but, despite the fact that his mother was financially well off, he entered as a sizar. A sizar at Cambridge was a student who received an allowance toward college expenses in exchange for acting as a servant to other students. There is certainly some ambiguity in his position as a sizar, for he seems to have associated with "better class" students rather than other sizars. Westfall (see [23] or [24]) has suggested that Newton may have had Humphrey Babington, a distant relative who was a Fellow of Trinity, as his patron. This reasonable explanation would fit well with what is known and mean that his mother did not subject him unnecessarily to hardship as some of his biographers claim.

Newton's aim at Cambridge was a law degree. Instruction at Cambridge was dominated by the philosophy of Aristotle but some freedom of study was allowed in the third year of the course. Newton studied the philosophy of Descartes, Gassendi, Hobbes, and in particular Boyle. The mechanics of the Copernican astronomy of Galileo attracted him and he also studied Kepler's *Optics.* He recorded his thoughts in a book which he entitled *Quaestiones Quaedam Philosophicae* (Certain Philosophical Questions). It is a fascinating account of how Newton's ideas were already forming around 1664. He headed the text with a Latin statement meaning

"Plato is my friend, Aristotle is my friend, but my best friend is truth" showing himself a free thinker from an early stage.

How Newton was introduced to the most advanced mathematical texts of his day is slightly less clear. According to de Moivre, Newton's interest in mathematics began in the autumn of 1663 when he bought an astrology book at a fair in Cambridge and found that he could not understand the mathematics in it. Attempting to read a trigonometry book, he found that he lacked knowledge of geometry and so decided to read Barrow's edition of Euclid's *Elements.* The first few results were so easy that he almost gave up but he:-

... changed his mind when he read that parallelograms upon the same base and between the same parallels are equal.

Returning to the beginning, Newton read the whole book with a new respect. He then turned to Oughtred's *Clavis Mathematica* and Descartes' *La Géométrie.* The new algebra and analytical geometry of Viète was read by Newton from Frans van Schooten's edition of Viète's collected works published in 1646. Other major works of mathematics which he studied around this time was the newly published major work by van Schooten *Geometria a Renato Des Cartes* which appeared in two volumes in 1659-1661. The book contained important appendices by three of van Schooten's disciples, Jan de Witt, Johan Hudde, and Hendrick van Heuraet. Newton also studied Wallis's *Algebra* and it appears that his first original mathematical work came from his study of this text. He read Wallis's method for finding a square of equal area to a parabola and a hyperbola which used indivisibles. Newton made notes on Wallis's treatment of series but also devised his own proofs of the theorems writing:-

Thus Wallis doth it, but it may be done thus ...

It would be easy to think that Newton's talent began to emerge on the arrival of Barrow to the Lucasian chair at Cambridge in 1663 when he became a Fellow at Trinity College. Certainly the date matches the beginnings of Newton's deep mathematical studies. However, it would appear that the 1663 date is merely a coincidence and that it was only some years later that Barrow recognised the mathematical genius among his students.

Despite some evidence that his progress had not been particularly good, Newton was elected a scholar on 28 April 1664 and received his bachelor's degree in April 1665. It would appear that his scientific genius had still not emerged, but it did so suddenly when the plague closed the University in the summer of 1665 and he had to return to Lincolnshire. There, in a period of less than two years, while Newton was still under 25 years old, he began revolutionary advances in mathematics, optics, physics, and astronomy.

While Newton remained at home he laid the foundations for differential and integral calculus, several years before its independent discovery by Leibniz. The 'method of fluxions', as he termed it, was based on his crucial insight that the integration of a function is merely the inverse procedure to differentiating it. Taking differentiation as the basic operation, Newton produced simple analytical methods that unified many separate techniques previously developed to solve apparently unrelated problems such as finding areas, tangents, the lengths of curves and the maxima and minima of functions. Newton's *De Methodis Serierum et Fluxionum* was written in 1671 but Newton failed to get it published and it did not appear in print until John Colson produced an English translation in 1736.

When the University of Cambridge reopened after the plague in 1667, Newton put himself forward as a candidate for a fellowship. In October he was elected to a minor fellowship at Trinity College but, after being awarded his Master's Degree, he was elected to a major fellowship in July 1668 which allowed him to dine at the Fellows' Table. In July 1669 Barrow tried to ensure that Newton's mathematical achievements became known to the world. He sent Newton's text *De Analysi* to Collins in London writing:-

[*Newton*] *brought me the other day some papers, wherein he set down methods of calculating the dimensions of magnitudes like that of Mr Mercator concerning the hyperbola, but very general; as also of resolving equations; which I suppose will please you; and I shall send you them by the next.*

Collins corresponded with all the leading mathematicians of the day so Barrow's action should have led to quick recognition. Collins showed Brouncker, the President of the Royal Society, Newton's results (with the author's permission) but after this Newton requested that his manuscript be returned. Collins could not give a detailed account but de Sluze and Gregory learnt something of Newton's work through Collins. Barrow resigned the Lucasian chair in 1669 to devote himself to divinity, recommending that Newton (still only 27 years old) be appointed in his place. Shortly after this Newton visited London and twice met with Collins but, as he wrote to Gregory:-

... having no more acquaintance with him I did not think it becoming to urge him to communicate anything.

Newton's first work as Lucasian Professor was on optics and this was the topic of his first lecture course begun in January 1670. He had reached the conclusion during the two plague years that white light is not a simple entity. Every scientist since Aristotle had believed that white light was a basic single entity, but the chromatic aberration in a telescope lens convinced Newton otherwise. When he passed a thin beam of sunlight through a glass prism Newton noted the spectrum of colours that was formed.

He argued that white light is really a mixture of many different types of rays which are refracted at slightly different angles, and that each different type of ray produces a different spectral colour. Newton was led by this reasoning to the erroneous conclusion that telescopes using refracting lenses would always suffer chromatic aberration. He therefore proposed and constructed a reflecting telescope.

In 1672 Newton was elected a fellow of the Royal Society after donating a reflecting telescope. Also in 1672 Newton published his first scientific paper on light and colour in the *Philosophical Transactions of the Royal Society.* The paper was generally well received but Hooke and Huygens objected to Newton's attempt to prove, by experiment alone, that light consists of the motion of small particles rather than waves. The reception that his publication received did nothing to improve Newton's attitude to making his results known to the world. He was always pulled in two directions, there was something in his nature which wanted fame and recognition yet another side of him feared criticism and the easiest way to avoid being criticised was to publish nothing. Certainly one could say that his reaction to criticism was irrational, and certainly his aim to humiliate Hooke in public because of his opinions was abnormal. However, perhaps because of Newton's already high reputation, his corpuscular theory reigned until the wave theory was revived in the 19th century.

Newton's relations with Hooke deteriorated further when, in 1675, Hooke claimed that Newton had stolen some of his optical results. Although the two men made their peace with an exchange of polite letters, Newton turned in on himself and away from the Royal Society which he associated with Hooke as one of its leaders. He delayed the publication of a full account of his optical researches until after the death of Hooke in 1703. Newton's *Opticks* appeared in 1704. It dealt with the theory of light and colour and with

i. investigations of the colours of thin sheets
ii. 'Newton's rings' and
iii. diffraction of light.

To explain some of his observations he had to use a wave theory of light in conjunction with his corpuscular theory.

Another argument, this time with the English Jesuits in Liège over his theory of colour, led to a violent exchange of letters, then in 1678 Newton appears to have suffered a nervous breakdown. His mother died in the following year and he withdrew further into his shell, mixing as little as possible with people for a number of years.

Newton's greatest achievement was his work in physics and celestial mechanics, which culminated in the theory of universal gravitation. By 1666 Newton had early versions of his three laws of motion. He had also discovered the law giving the centrifugal force on a body moving uniformly in a circular path. However he did not have a correct understanding of the mechanics of circular motion.

Newton's novel idea of 1666 was to imagine that the Earth's gravity influenced the Moon, counter- balancing its centrifugal force. From his law of centrifugal force and Kepler's third law of planetary motion, Newton deduced the inverse-square law.

In 1679 Newton corresponded with Hooke who had written to Newton claiming:-

... that the Attraction always is in a duplicate proportion to the Distance from the Center Reciprocall ...

M Nauenberg writes an account of the next events:-

After his 1679 *correspondence with Hooke, Newton, by his own account, found a proof that Kepler's areal law was a consequence of centripetal forces, and he also showed that if the orbital curve is an ellipse under the action of central forces then the radial dependence of the force is inverse square with the distance from the centre.*

This discovery showed the physical significance of Kepler's second law.

In 1684 Halley, tired of Hooke's boasting [M Nauenberg]:-

... asked Newton what orbit a body followed under an inverse square force, and Newton replied immediately that it would be an ellipse. However in 'De Motu..' he only gave a proof of the converse theorem that if the orbit is an ellipse the force is inverse square. The proof that inverse square forces imply conic section orbits is sketched in Cor. 1 *to Prop.* 13 *in Book* 1 *of the second and third editions of the 'Principia', but not in the first edition.*

Halley persuaded Newton to write a full treatment of his new physics and its application to astronomy. Over a year later (1687) Newton published the *Philosophiae naturalis principia mathematica* or *Principia* as it is always known.

The *Principia* is recognised as the greatest scientific book ever written. Newton analysed the motion of bodies in resisting and non-resisting media under the action of centripetal forces. The results were applied to orbiting bodies, projectiles, pendulums, and free-fall near the Earth. He further demonstrated that the planets were attracted toward the Sun by a force varying as the inverse square of the distance and generalised that all heavenly bodies mutually attract one another.

Further generalisation led Newton to the law of universal gravitation:-

... all matter attracts all other matter with a force proportional to the product of their masses and inversely proportional to the square of the distance between them.

Newton explained a wide range of previously unrelated phenomena: the eccentric orbits of comets, the tides and their variations, the precession of the Earth's axis, and motion of the Moon as perturbed by the gravity of the Sun. This work made Newton an international leader in scientific research. The Continental scientists certainly did not accept the idea of action at a distance and continued to believe in Descartes' vortex theory where forces work through contact. However this did not stop the universal admiration for Newton's technical expertise.

James II became king of Great Britain on 6 February 1685. He had become a convert to the Roman Catholic church in 1669 but when he came to the throne he had strong support from Anglicans as well as Catholics. However rebellions arose, which James put down but he began to distrust Protestants and began to appoint Roman Catholic officers to the army. He then went further, appointing only Catholics as judges and officers of state. Whenever a position at Oxford or Cambridge became vacant, the king appointed a Roman Catholic to fill it. Newton was a staunch Protestant and strongly opposed to what he saw as an attack on the University of Cambridge.

When the King tried to insist that a Benedictine monk be given a degree without taking any examinations or swearing the required oaths, Newton wrote to the Vice-Chancellor:-

Be courageous and steady to the Laws and you cannot fail.

The Vice-Chancellor took Newton's advice and was dismissed from his post. However Newton continued to argue the case strongly preparing documents to be used by the University in its defence. However William of Orange had been invited by many leaders to bring an army to England to defeat James. William landed in November 1688 and James, finding that Protestants had left his army, fled to France. The University of Cambridge elected Newton, now famous for his strong defence of the university, as one of their two members to the Convention Parliament on 15 January 1689. This Parliament declared that James had abdicated and in February 1689 offered the crown to William and Mary. Newton was at the height of his standing - seen as a leader of the university and one of the most eminent mathematicians in the world. However, his election to Parliament may have been the event which let him see that there was a life in London which might appeal to him more than the academic world in Cambridge.

After suffering a second nervous breakdown in 1693, Newton retired from research. The reasons for this breakdown have been discussed by his biographers and many theories have been proposed: chemical poisoning as a result of his alchemy experiments; frustration with his researches; the ending of a personal friendship with Fatio de Duillier, a Swiss-born mathematician resident in London; and problems resulting from his religious beliefs. Newton himself blamed lack of sleep but this was almost certainly a symptom of the illness rather than the cause of it. There seems little reason to suppose that the illness was anything other than depression, a mental illness he must have suffered from throughout most of his life, perhaps made worse by some of the events we have just listed.

Newton decided to leave Cambridge to take up a government position in London becoming Warden of the Royal Mint in 1696 and Master in 1699. However, he did not resign his positions at Cambridge until 1701. As Master of the Mint, adding the income from his estates, we see that Newton became a very rich man. For many people a position such as Master of the Mint would have been treated as simply a reward for their scientific achievements. Newton did not treat it as such and he made a strong contribution to the work of the Mint. He led it through the difficult period of recoinage and he was particularly active in measures to prevent counterfeiting of the coinage.

In 1703 he was elected president of the Royal Society and was re-elected each year until his death. He was knighted in 1705 by Queen Anne, the first scientist to be so honoured for his work. However the last portion of his life was not an easy one, dominated in many ways with the controversy with Leibniz over which of them had invented the calculus.

Given the rage that Newton had shown throughout his life when criticised, it is not surprising that he flew into an irrational temper directed against Leibniz. We have given details of this controversy in Leibniz's biography and refer the reader to that article for details. Perhaps all that is worth relating here is how Newton used his position as President of the Royal Society. In this capacity he appointed an "impartial" committee to decide whether he or Leibniz was the inventor of the calculus. He wrote the official report of the committee (although of course it did not appear under his name) which was published by the Royal Society, and he then wrote a review (again anonymously) which appeared in the *Philosophical Transactions of the Royal Society*.

Newton's assistant Whiston had seen his rage at first hand. He wrote:-

Newton was of the most fearful, cautious and suspicious temper that I ever knew.

Article by: *J J O'Connor* and *E F Robertson*

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MacTutor History of Mathematics
[http://www-history.mcs.st-andrews.ac.uk/Biographies/Newton.html]

From: http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Newton.html