# Robert Hooke

**Born: 18 July 1635 in Freshwater, Isle of Wight, England**
**Died: 3 March 1703 in London, England**

**Robert Hooke**'s father was John Hooke who was a curate at All Saints Church in Freshwater on the Isle of Wight. Although formally a curate, since the minister was also Dean of Gloucester Cathedral and of Wells, John Hooke was left in charge of All Saints. It was a well off church being in the patronage of St John's College, Cambridge. As well as his duties in the church, John Hooke also ran a small school attached to the church and acted as a private tutor. Robert had a brother named John, the same as his father, who was five years older.

Relatively few details of Robert's childhood are known. What we record here is information which he mentioned to his friends later in his life. Robert, like many children of his day, had poor health and was not expected to reach adulthood. His father was from a family in which it was expected that all the boys joined the Church (John Hooke's three brothers were all ministers) so had Robert enjoyed good health as a child there is no doubt that he would have followed the family tradition. As it was Robert's parents did begin to set up his education with this in mind but he continually suffered from headaches which made studying hard. Lacking confidence that he would reach adulthood, Robert's parents gave up on his education, leaving him much to his own devices.

Robert's own ideas involved his observational skills and his mechanical skills. He observed the plants, the animals, the farms, the rocks, the cliffs, the sea, and the beaches around him. He was fascinated by mechanical toys and clocks, making many things from wood from a working clock to a model of a fully rigged ship with working guns. Waller, in the Preface to Hooke's *Posthumous Works* published in 1705, dates his belief in mechanics, in particular his belief that nature was a complicated machine, from the time that he let his imagination and his talents run riot at about age ten.

From about the time Robert was ten his father became ill and this contributed to Robert being left to educate himself in the highly practical way that interested him. Not only did Robert show talents at science, but he also showed skills at drawing. There was a portrait painter, John Hoskyns, who was working at Freshwater at this time and Robert used to watch him at work. Soon he was imitating the way that Hoskyns used pen and chalk, and he was making copies of Hoskyns' portraits. His talent was clear and after the death of his father in 1648 Robert's family decided that drawing was the best way that he might earn a living. He was left £40 by his father, together with all his father's books (the often quoted figure of £100 is a much repeated error), and his family sent him to London to become an apprentice to the Peter Lely, a portrait painter.

Lely had studied at Haarlem in Holland and set himself up in London about five years before Hooke was sent to him. Lely quickly gained fame painting portraits of Charles I and James, Duke of York. Influenced by Van Dyck he became the most technically proficient painter in England and Hooke could have learnt much from such a leading expert. However, he soon decided that it would waste his money studying under Lely, and he made the decision that what he really needed was a school education. Hooke enrolled in Westminster School, boarding in the house of the headmaster Richard Busby. Indeed Hooke was fortunate to come under the influence of Busby who was an outstanding teacher who quickly realised that he had a quite remarkable pupil. Hooke had mastered the first six books of Euclid's *Elements* by the end of his first week at school but Busby seemed to understand that formal learning was not going to be best for Hooke and so encouraged him to study by himself in his library [10]:-

*Hooke was fortunate in gaining the respect of Dr Busby and being left to follow his own pursuits of knowledge just as he had before attending Westminster School.*

At Westminster Hooke learnt Latin and Greek but, although he enjoyed speaking Latin, unlike his contemporaries he never wrote in Latin. His rapidly gained understanding of geometry was soon applied to his real love of mechanics and he began to invent possible flying machines. Music was another of his interests and he learnt to play the organ. In 1653, feeling that he had assimilated as much knowledge as Westminster School could offer, he entered Christ College, Oxford where he won a chorister's place. He began to study at Oxford at a particularly significant time for Thomas Willis, Seth Ward, Robert Boyle, John Wilkins, John Wallis, Christopher Wren and William Petty were among those who regularly met as the "Oxford branch" of the "invisible college" or the "philosophical college" which had been set up in 1648-49 when some of the scientists meeting in London moved to Oxford.

In Oxford Hooke learnt astronomy from Seth Ward and impressed Wilkins with his knowledge of mechanics. Wilkins gave him a copy of his book *Mathematical Magick, or the wonders that may be performed by mechanical geometry* which he had published five years before Hooke arrived in Oxford. This book encouraged Hooke to continue to try to invent a flying machine and he conducted experiments in the grounds of Wadham College with pulleys. For a while Hooke assisted Willis with his dissection experiments. He was involved with the top English scientists of the day, benefiting greatly by acquiring skills in a wide range of disciplines [1]:-

*... Hooke never took a bachelor's degree* [*but*] *Oxford had given him more than a thousand degrees could match.*

Boyle was looking for an assistant and Willis recommended Hooke to him. From 1655 he was employed by Boyle and his first project was to construct an air pump. The main area of Boyle's interests were in chemistry but he had read of experiments conducted by von Guericke with the aid of an air pump and, knowing Hooke's skill with mechanical instruments, asked him if he could build one. A better air pump than that used by von Guericke had been made by Greatorix but Hooke felt that he could improve on the design. Indeed he did so and Hooke designed and built what is essentially the modern air pump.

Hooke was never a person who did one thing at a time, indeed he seemed at his best when his mind was jumping from one idea to another. At the same time that he was working on the air pump he was also thinking about clocks and how they could be used in determining the longitude at sea. Realising the weakness of the pendulum clock in keeping time on a ship which was pitching and tossing, he wondered about the:-

*... use of springs instead of gravity for making a body vibrate in any posture.*

Rather than the balance wheel being controlled by a pendulum which in turn operated through gravity, he reasoned that controlling the balance wheel with a spring would have huge advantages for a portable timekeeper that one might carry around or one which would have to continue to keep the correct time on a ship. Beginning his experiments around 1658 he had made two significant steps by 1660, namely the use of a balance controlled by a spiral spring and an improved escapement called the anchor escapement. In 1660 he discovered an instance of Hooke's law while working on designs for the balance springs of clocks. However he only announced the general law of elasticity in his lecture *Of Spring* given in 1678.

In fact 1660 was the year when a rather strange event happened regarding Hooke's spring controlled clocks. In that year he was backed by Wren, Moray and Brouncker in his design of a spring controlled clock and a patent was drawn up. It could have led to him making a fortune, but when he realised that the patent would allow anyone who improved on his design to receive the royalties, he refused to continue with the patent.

Political circumstances now determined the course of events. After Cromwell's death in 1658 his son took over but was ineffectual. Many of the scientists in Oxford had been appointed because of their Puritan sympathies and they now lost their positions and moved to London. Monck, who had been appointed as governor in Scotland, marched an army on London and restored order in early 1660. Monck called for new elections to Parliament, knowing that the mood of the people would elect Royalists. The improvement in the situation in London, in particular troops which had been stationed in Gresham College now left, allowed the scientists to begin meeting again in the College. On Wednesday 28 November 1660 a meeting in Gresham College constituted the Society for the Promoting of Physico-Mathematical Experimental Learning which they declared would promote experimental philosophy.

Hooke's first publication was a pamphlet on capillary action. On 10 April 1661 his paper was read to the Society in which he showed that the narrower the tube, the higher water rose in it. The Society at Gresham had by this time petitioned King Charles II to recognise it and to make a royal grant of incorporation. The Royal Charter, which was passed by the Great Seal on 15 July 1662, created the Royal Society of London and the Royal Charter contained a provision to appoint a Curator of Experiments. The Society already had in mind appointing Hooke to this position and indeed on 5 November 1662 he was given the position. In many ways it did not look a marvellous deal for he was required to demonstrate three or four experiments at every meeting of the Society, something that was quite unrealistic and it is doubtful that anyone other than Hooke could have contemplated being able to provide. Although it was hoped that the Society would eventually be able to provide payment to Hooke, he was required to undertake the work without any recompense until the Society was in a position to do so.

In fact Hooke reacted to the impossible task set him by producing a wealth of original ideas over the following 15 years. It would be fair to say that it was through Hooke's flood of ideas that the Society prospered, but equally the demands brought out Hooke's genius to the full. Although the demands meant that he never had time to develop his ideas over time as one would expect a leading scientist to do, on the other hand it seemed to suit his nature to have his mind jump for one half thought out idea to the next. He was elected to the Royal Society on 3 June 1663 and, although he was still receiving no payment, at least the Society was prepared to allow him to become a Fellow without paying the annual fees.

In 1664 the Society agreed to pay Hooke a salary of £80 per year but shortly after this they arranged the position of Cutlerian Lecturer in the Mechanical Arts for him at a salary of £50 per year and then reduced his salary as Curator of Experiments to £30 but gave him an appointment for life. This did not provide the financial security that Hooke might have hoped for, since the Society often did not have sufficient funds to pay him as Curator of Experiments and when he was not paid for his duties as Cutlerian Lecturer in the Mechanical Arts he was forced to go to court to get payment.

He did however secure another appointment, namely that of Professor of Geometry at Gresham College, London, being appointed there in 1665. The position gave him rooms at the College and required him to give one lecture each week in term time. The lecture had to be given in Latin and subsequently repeated in English. He was required to be unmarried but was permitted a housekeeper.

The year 1665 was the one when Hooke first achieved worldwide scientific fame. His book *Micrographia*, published that year, contained beautiful pictures of objects Hooke had studied through a microscope he had made himself. The book also contains a number of fundamental biological discoveries. Pepys wrote in his diary:-

*Before I went to bed I sat up till two o'clock in my chamber reading Mr Hooke's Microscopical Observations, the most ingenious book that ever I read in my life.*

Westfall writes [1]:-

*Micrographia remains one of the masterpieces of seventeenth century science. ...* [*it*] *presented not a systematic investigation of any one question, but a bouquet of observations with courses from the mineral, animal and vegetable kingdoms. Above all, the book suggested what the microscope could do for biological science.*

Hooke invented the conical pendulum and was the first person to build a Gregorian reflecting telescope. He made important astronomical observations including the fact that Jupiter revolves on its axis which he discovered from observing spots. He then invented a helioscope to attempt to measure the rotation of the sun using sunspots. He made drawings of Mars which were later used to determine its period of rotation. He observed several comets and asked a number of important questions about them, including why the tail points away from the sun, and how if the comet is burning it could burn for so long and burn in a place where there is no air. In 1666 he proposed that gravity could be measured using a pendulum.

In addition to his post as Professor of Geometry at Gresham College, Hooke held the post of City Surveyor. He was a very competent architect and was chief assistant to Wren in his project to rebuild London after the Great Fire of 1666. Westfall writes [1]:-

*Wren and Hooke dominated and guided the work, and cemented a friendship that lasted throughout their lives. To Hooke the position of surveyor was a financial boon, more than compensating for the uncertainty of his other income.*

When Newton produced his theory of light and colour in 1672, Hooke claimed that what was correct in Newton's theory was stolen from his own ideas about light of 1665 and what was original was wrong. This marked the beginning of severe arguments between the two. In 1672 Hooke attempted to prove that the Earth moves in an ellipse round the Sun and six years later proposed that inverse square law of gravitation to explain planetary motions. Hooke wrote to Newton in 1679 asking for his opinion:-

*... of compounding the celestiall motions of the planetts of a direct motion by the tangent* (*inertial motion*) *and an attractive motion towards the centrall body ... my supposition is that the Attraction always is in a duplicate proportion to the Distance from the Center Reciprocall ...*

Hooke, however, seemed unable to give a mathematical proof of his conjectures or perhaps unwilling to devote his time to this type of pursuit. However he claimed priority over the inverse square law and this led to a bitter dispute with Newton who, as a consequence, removed all references to Hooke from the *Principia.*

Frequent bitter disputes with fellow scientists occurred throughout Hooke's life. On the other hand, we should note that he was on very good terms with some colleagues, particularly Boyle and Wren. Historians have described Hooke as a difficult and unreasonable man but in many ways this is a harsh judgement. There is no doubt that Hooke genuinely felt that others had stolen ideas which he had been first to put forward. It is easy to see why this happened. Hooke did indeed come up with a vast range of brilliant ideas many of which were claimed by others not because they wished to steal them from him, but rather because Hooke never followed through developing his ideas into building comprehensive theories. He failed to develop major theories from his inspired ideas for the simple reason that he did not really have the technical ability to develop such comprehensive theories as some of his contemporaries like Newton and Huygens.

The diaries of Hooke are fascinating documents in that they tell us something about his character as well as painting an interesting picture of his times. Here are some examples taken from [10]:-

*He was a brisk walker, and enjoyed walking in the fields north of the City. ... he generally rose early, perhaps to save candles, and to work in daylight and prevent strain to his eyes. ... Sometimes Hooke would work all through the night, and then have a nap after dinner. As well as drinking a variety of waters ... he drank brandy, port, claret, sack, and birch juice wine which he found to be delicious. He also had a barrel of Flanstead's ale and Tillotson's ale. There are a few instances when he recorded that he had been drunk ... He was a gregarious person, who liked to meet people, particularly those who had travelled abroad ...*

As Hooke grew older he became more cynical and would shut himself away from company. The papers which he wrote in the last few years of his life are filled with bitter comments. In February 1690 Hooke gave two lectures to the Royal Society which are reproduced in part in [26]. At this time, according to Waller [11], Hooke was:-

*.. often troubled with headaches, giddiness, and fainting, and with a general decay all over, which hindered his philosophical studies, yet he still read some lectures whenever he was able.*

Hooke shows how bitter he feels in these lectures. For example, in the second lecture he said:-

[*Huygens' Preface*] *is concerning those properties of gravity which I myself first discovered and showed to this Society and years since, which of late Mr Newton has done me the favour to print and publish as his own inventions. And particularly that of the oval figure of the Earth which was read by me to this Society about* 27 *years since upon the occasion of the carrying the pendulum clocks to sea and at two other times since, though I have had the ill fortune not to be heard, and I conceive there are some present that may very well remember and do know that Mr Newton did not send up that addition to his book till some weeks after I had read and showed the experiments and demonstration thereof in this place and had answered the reproachful letter of Dr Wallis from Oxford. However I am well pleased to find that the truth will at length prevail when men have laid aside their prepossessions and prejudices. And as that hath found approvers in the world and those thinking men too, so I doubt not but that divers other discoveries which I have here first made* (*when they come to be well considered and examined*) *be found not so unreasonable or extravagant as some would willingly make them.*

After his death Waller edited [11], a major publication of previously unpublished works by Hooke. A large portion of this work is devoted to Hooke's lectures on earthquakes. Over a period of thirty years he made major contributions to geology, particularly his investigation of fossil remains which convinced him that major changes had occurred in the Earth's surface which had lifted fossilised shells of marine animals to high points in mountain ranges.

Hooke has been described as a:-

*... lean, bent and ugly man ...*

and so it was believed that he did not sit for a portrait. However, a portrait painted for the Royal Society has recently been found after being missing for many years.

**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/Hooke.html]

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