

The Life and Achievements of George Green

School

In 1801, at the age of eight years, young George Green started school at Mr Goodacre's Academy in Nottingham. George's father was a baker in the town and the school fees must have been a considerable expense for him. Perhaps George was already showing signs of the genius for mathematics that became evident in his later life. His cousin, William Tomlin, writing after George Green's death, said that 'at a very early age . . . he pursued with undeviating constancy the same as in his mature years an intense application to mathematics.'

Mr Goodacre was a noted teacher and one who encouraged scientific enquiry, equipping the school with such instruments as a barometer, thermometer, air pump, an orrery to show the motion of the moon and planets and astronomical telescopes. George flourished at the school and William Tomlin tells us that George's 'profound knowledge in the mathematics' soon exceeded his schoolmaster's. However, George attended the Academy for only four terms, leaving at the age of nine years to work in his father's bakery.



Goodacre's Academy

A Working Miller



The mill and Mill House c.1860

The bakery prospered and in 1807 Mr Green bought a plot of land in Sneinton, then a village outside of the town of Nottingham, where he built the fine brick windmill which still stands to this day. Later the family moved out of the town to a splendid new house next to the mill.

At some time Mr Green appointed as mill manager William Smith who took residence in the cottage built onto the side of the mill. He had a daughter Jane who, at the age of twenty two, bore George Green a daughter. Jane and George never married although over a relationship lasting some sixteen years they had seven children in all. Perhaps old Mr Green did not approve of his son marrying the daughter of an employee. Or perhaps it has something to do with George's other life as a mathematician. As we shall see George eventually became a Fellow at Cambridge University, a condition of which at that time was that one had to be unmarried.

Intellectual opportunity

In 1823 George Green joined the Bromley House Library in Nottingham. At a time before the establishment of a University in Nottingham, Bromley House was the meeting place of intellectuals and academics, the setting for cultural activities, lectures and exhibitions. The library gave George access to some scientific publications, for example the Transactions of the Royal Society, and his introduction to the world of learning wherein he was later to achieve so much. The library still exists in Nottingham, an oasis of calm in the bustle of the busy city centre.

The President of the library at that time was the Rev. Robert White Almond, a mathematics graduate and probably someone who encouraged George's interests. Another notable local mathematician who almost certainly helped George was the Rev. John Toplis, Headmaster of the Free Grammar School. Toplis was very dissatisfied with the style of mathematics taught in England at that time, a style which still used the old Newtonian notation. Toplis championed the work of Leibnitz, a German contemporary of Newton, who used a different way of writing mathematics, one which is used to this day. Scientists on the Continent had made great advances in applying mathematics to the understanding of problems in physics but little of this had become known in England. Toplis tried to remedy this, for example with his translation of the *Mécanique Céleste* by LaPlace. George Green and his family lived around the corner from Toplis for some time and, despite direct evidence, it is inconceivable that the two men, with such a particular interest in common and in such a small society, did not have much to share.

The Essay of 1828

What we do know is that in 1828, at the age of thirty five years, George published his greatest work 'An Essay on the Application of Mathematical Analysis to the Theories of Electricity and Magnetism'. Published at the author's expense, it had fifty-one subscribers, about half of whom were members of Bromley House Library. They each paid the large sum of seven shillings and sixpence for their copy though few could have understood any part of it nor have had any idea of the significance of the event. The ideas and concepts in it were in advance of their time, written in the unfamiliar Continental notation and containing ideas and techniques which are known to this day as Green's functions and Green's Theorem.

In the Essay Green applied mathematical analysis or calculation to the contemporary theories of electricity and magnetism. It was one of the first attempts to apply mathematical theory to electrical phenomena and was of such importance that it has been described as 'the beginning of mathematical physics in England' and 'a major work of striking originality' whose publication was the 'most significant event in the intellectual history of Nottingham'.

Yet, despite the astonishing achievement that the Essay is now seen to be, it went unregarded at the time. Green, busy by day with his milling business, had laboured long over the work in, as he put it, 'the hours stolen from my sleep'. Yet to no avail, it seemed. George put aside mathematics and turned his attentions to the mill, his business interests and his growing family.

Genius discovered

That might have been the end of the story, the Essay standing as the single achievement of this remarkable man. However, one of the subscribers to the Essay was Sir Edward Bromhead of Thurlby Hall near Lincoln. Bromhead, a landowner, magistrate and High Steward of Lincoln, was also a gifted mathematician who recognised the potential of Green's work. He made inquiries about Green from an acquaintance in Nottingham who replied

10 May 1828 Sir,

I learn from Nottingham that Mr G Green is the Son of a Miller, who has had only a common education in the Town, but has been ever since his mind could appreciate the value of learning immoderately fond of Mathematical pursuits, and which attainments have been acquired wholly by his own perseverance unassisted by any Tutor or Preceptor; he is now only 26 or 27 years of age of rather reserved habits attends the business of the Mill, yet finds time for his favourite Mathematical reading-

Your obt. servant

Thos Fisher

A rare glimpse of the personality of George Green - who was actually 35 years old at the time.

Yet it was two years before good fortune put George Green in communication with Bromhead. He invited Green to Thurlby Hall, thus starting a remarkable relationship between the Nottingham miller and the baronet.

Bromhead encouraged Green to write three further 'memoirs', two of which Bromhead caused to be published by the Cambridge Philosophical Society. One was 'Mathematical Investigations Concerning the Laws of Equilibrium of Fluids analogous to the Electric Fluid' and the other 'On the Determination of Exterior and Interior Attractions of Ellipsoids of Variable Densities'.

At the same time Green was working on hydrodynamics and his paper 'Researches on the Vibrations of Pendulums in Fluid Media' was sent by Bromhead to the Royal Society of Edinburgh, of which he was a Fellow. Green now had a growing reputation and could perhaps have taken his place amongst the eminent men of science of his time. However, he was still aware that he was a working miller whereas the acquaintances of Bromhead were very much gentlemen. Bromhead's friends at Cambridge had included Charles Babbage who later did so much on 'calculating engines', John Herschel, son of the Astronomer Royal William Herschel and himself to become a noted astronomer and George Peacock, later to be a Professor of Astronomy.

In 1833 Bromhead invited Green to meet some of his old friends at Cambridge. Green replied 'You were kind enough to mention a journey to Cambridge on June 24th to see your friends Herschel, Babbage and others who constitute the Chivalry of British Science. Being as yet only a beginner I think I have no right to go there and must defer that pleasure until I shall have become tolerably respectable as a man of science should that day ever arrive.'

Cambridge

The possibility of his going to Cambridge as a student had already been mentioned by Green earlier that year '... you are aware that I have an inclination for Cambridge if there was a fair prospect of success. Unfortunately I possess little Latin and less Greek and have seen too many winters, and am thus held in a state of suspense by counteracting motives.' Bromhead recommended his own college of Gonville and Caius where he had influence. Green leased out the milling business and the family house, resigned from Bromley House Library and in October 1833 was admitted as an undergraduate to Caius College. He was forty years old.

Many of the undergraduates at the college did not come for the higher learning that the University could offer. They were sent by their families to complete their education and there were many temptations placed before them. The poet Byron, there in 1807, has written to a friend '*This place is wretched enough - a villainous chaos of sin and drunkenness: nothing but Hazard and Burgundy, hunting, mathematics and Newmarket, riot and racing . . . We have several parties here and this evening a large assortment of jockeys, gamblers, boxers, authors, parsons and poets, sup with me - a precious mixture but they get on well together.*'

Whilst such a life may have suited Byron it is likely that Green spent his time more industriously for, as well as studying mathematics, he had to pass examinations in Latin, Greek and Ecclesiastical History. Green was listed as Fourth Wrangler in the Senate House examination in January 1837 and his reputation stood high. He was awarded the Perse Fellowship at Caius which gave him a very modest allowance of ten pounds per annum, presumably enough to allow him to continue his studies. Green published further papers, this time on wave theory: two on hydrodynamics of wave motion, two on the reflection and refraction of sound waves and two upon the reflection and refraction of light.

AN ESSAY

ON THE

APPLICATION

OF

MATHEMATICAL ANALYSIS TO THE THEORIES OF
ELECTRICITY AND MAGNETISM.

BY

GEORGE GREEN.

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1828.



Gate of Honor, Caius College, Cambridge.

Bishop Harvey Goodwin, at that time an undergraduate at Cambridge, later wrote of Green that *'He stood head and shoulders above all his contemporaries inside and outside the University.'*



Green's grave in the churchyard close to his mill

Alas, only six months after his election to the Fellowship, in 1840, Green returned to Nottingham for the last time. In the words of his cousin William Tomlin, *'He returned, indisposed after enjoying many years of excellent health in Sneinton, Alas, with the opinion that he should never recover from his illness and which became verified in little more than a year's time by his decease on 31st May 1841.'*

Green's obituary in the Nottingham Review reveals the lack of recognition of his achievements at that time.

In our obituary of last week, the death of Mr Green was announced; we believe he was the son of a miller, residing near to Nottingham but having a taste for study, he applied his gifted mind to the science of mathematics, in which he made rapid progress. In Sir Edward French Bromhead, Bart., he found a warm friend, and to his influence he owed much, while studying at Cambridge. Had his life been prolonged he might have stood eminently high as a mathematician.

George Green 'might not have stood eminently high' in his lifetime but that was certainly not the case in subsequent years and decades. The next generation of physicists such as William Thomson (later Lord Kelvin) and James Clerk-Maxwell discovered that Green's mathematics was immensely useful in their further researches into, for example, the nature of light, the electromagnetic field and electricity. In the 20th century his mathematics assumed even greater importance in the new science of quantum physics, for example, Albert Einstein, in a lecture at Nottingham University, turned to Green's Essay of 1828, remarking that Green was 20 years ahead of his time. Later Richard Feynman and others used Green's mathematics in developing quantum electrodynamics. Indeed, the famous Feynman Diagrams – visual representations of the behaviour patterns of interacting particles – are essentially Green's maths in graphic form.

In 1993, on the bicentenary of his birth, George Green was honoured by the dedication of a memorial plaque in Westminster Abbey. It is close to the grave of Sir Isaac Newton and to memorials to those other great 19th century physicists Michael Faraday, William Thomson Kelvin and James Clerk-Maxwell. In the top corner of Green's memorial is carved a windmill.

