James Clerk Maxwell

Mainly known for his unifying theory of electricity, magnetism and induction, James Clerk Maxwell also concluded that light was an electromagnetic wave, and was responsible for the first true colour photograph.

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MAIN DATES

13 June 1831 Birth in Edinburgh (Scotland)	
1854	Smith's Prize at Cambridge University
1855	Fellow of Trinity College
1856	Fellow of the Royal Society of Edinburgh
1859	Adams Prize awarded by St John's College
1860	Rumford Medal of the Royal Society
1861	Fellow of the Royal Society
1865	First version of Maxwell's equations
1871	Chair of Experimental Physics at Cambridge
1871	Maxwell founds the Cavendish Laboratory in Cambridge
1873	Version of the Maxwell's equations written in quaternion notation
5 November 1879 Death in Cambridge (England)	

James Clerk Maxwell was born on 13 June 1831 in the family home in Edinburgh, but his childhood was spent not in the city but in the countryside, on the Clerk Maxwells' vast Glenlair estate in Kirkcudbrightshire. This environment provided the ideal stimulation for his insatiable natural curiosity. His father John Clerk, a prosperous lawyer related to the Clerk baronetcy of Penicuik, had taken the second surname Maxwell after inheriting the Glenlair estate through his connections with the Maxwell family. He and Frances Cay formed an unusual couple, as they had met at a relatively late age and Frances was nearly 40 when she gave birth to James, their sole surviving child.

A slow start

As was customary in those days, James was initially taught at home by his mother. She had intended to continue overseeing his education until he was 13 and old enough to go to university. However, she contracted stomach cancer and died when he was just 8. A young tutor was hired, but this arrangement soon fell through and it was decided that James should be sent to the prestigious Edinburgh Academy. Father and son therefore moved to the city to live with Isabella Wedderburn, John Clerk's sister, in November 1841.

James was now 10 years old. Having been brought up in the seclusion of the country estate, his mannerisms and accent were decidedly rustic and he was completely unused to the hustle and bustle of city life, making him appear shy and rather dull. His school début was inauspicious and his unusual interests in geometry and reading old ballads set him still further apart from his schoolmates. He did eventually find kindred spirits, however, including his lifelong friend Peter Guthrie Tait (1831-1901).

Turning point

His initial academic performances were mediocre, but his talent and genius were simmering just below the surface, and at 13 years, his gifts suddenly came to the fore and he ended the school year with the mathematical medal and several prizes in other subjects. The following year saw the publication of his first scientific paper, proposing a heuristic approach to oval curves.

In 1845, Maxwell left school for Edinburgh University, where he was soon dazzling his contemporaries. His classes left him plenty of time to improvise elegant physics experiments, including one in which he observed shear-induced double refraction in blocks of gelatine, using polarizing prisms given to him by William Nicol (1770-1851)! Maxwell was now 18, and that year published two groundbreaking papers.

In 1850, Maxwell left Scotland for Cambridge. He enrolled at the prestigious Trinity College, where he studied under William Hopkins (1793-1866), an academic known

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for his success in nurturing genius. The young James, already an accomplished mathematician, blossomed under his coaching, such that in 1854, he not only gained his degree in mathematics but was also joint winner of the prestigious Smith's Prize with Edward John Routh (1831-1907). He decided to stay on at Trinity and apply for a fellowship, which he was awarded the following year, charged with giving lectures on optics and hydrostatics.

Early work

Maxwell used coloured spinning tops invented by James Forbes (1809-1868) to demonstrate that white light results from a mixture of red, green and blue. He presented his paper "Experiments on Colour", in which he set out the principles of colour combination, to the Royal Society of Edinburgh in 1855. Colour perception was not his only interest, however, and in his paper "On Faraday's Lines of Force", he proposed a mathematical formulation of the theories propounded by Michael Faraday (1791-1867) and André-Marie Ampère (1775-1836) on electricity and magnetism.

In early 1856, learning that his father John Clerk Maxwell had fallen ill, James decided to return to Scotland. He heard that a chair of natural philosophy had fallen vacant at Marischal College in Aberdeen. He easily obtained the post, but his father died shortly afterwards, on 2nd April, leaving him all alone in the world at the age of just 25 years. James left Cambridge in November and was appointed head of department at Marischal College, in charge of planning the syllabus and preparing the lectures. He now divided his time between Aberdeen, where he lived for the six months of the university year, and the family home at Glenlair.

When St John's College, Cambridge, chose the stability of Saturn's rings as the theme of the 1857 Adams Prize, Maxwell took up the challenge and devoted his first two years of research at Aberdeen to the problem, which had been puzzling scientists for 200 years. Through pure mathematical reasoning, without the aid of experimental observations, he concluded that the rings must be made up of tiny particles orbiting the giant planet – a theory confirmed by the Voyager probe in the 1980s. Maxwell won the prize for what remains "one of the most remarkable applications of mathematics to physics" according to Georges Airy (1801-1892).

In 1857, Maxwell met Katherine Mary Dewar, the daughter of the Reverend Daniel Dewar, then Principal of Marischal College. They became engaged in February 1858, and were married in Aberdeen in June 1859. However, neither this family connection nor his established scientific status protected him when Marischal College merged with King's College to form Aberdeen University in 1860. There was only room for one professor of natural philosophy in this new structure, and being the younger of the two, Maxwell was forced to relinquish his post and look for one elsewhere.

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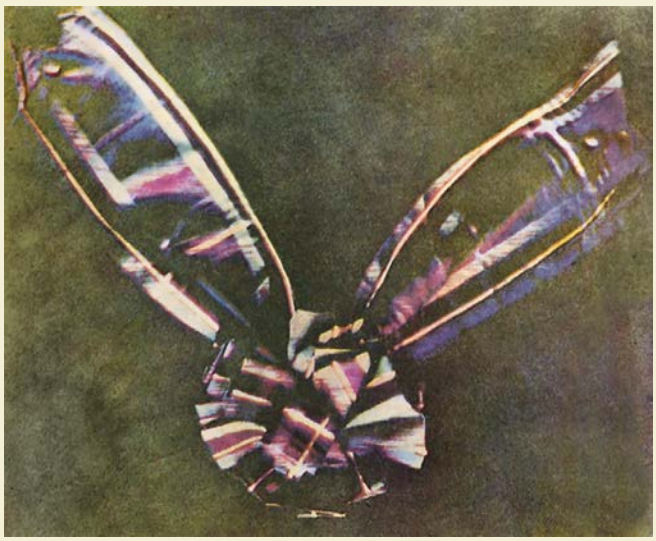

The first projected colour image : Maxwell's tartan ribbon (from Wikimedia Commons, in the public domain).

Giant steps for science

That same year, Forbes vacated the chair of natural philosophy at Edinburgh and Maxwell duly applied. However, he encountered fierce competition, not least from several of his friends, including Tait and Routh. Arguing with some justification that Maxwell was not the best person to teach poorly equipped students, the selection committee finally chose Tait.

Maxwell nevertheless managed to obtain the natural philosophy chair at King's College in London. He was to spend six years there, and although the teaching load was far heavier than it had been at Marischal College, he still managed to conduct some of his finest experiments during this period. His research on colour perception earned him the Royal Society's Rumford Medal in 1860. More noteworthy still, he succeeded in producing the first true colour photograph, using red, green and blue filters. He also developed his ideas on the kinetic theory of gases.

This period was above all remarkable for Maxwell's advances in electromagnetism. He was able to summarize all the connections between electricity and magnetism in a handful of equations, publishing an initial version of his work in 1865. This was prodigious feat of synthesis, as none of the laws he so brilliantly unified - and even extended, by substantially modifying Ampère's circuital law to make his unified description more coherent – was more than half a century old. He went even further, as his equations indicated that electromagnetic fields propagate as waves at approximately the speed of light, and he therefore deduced that light is an electromagnetic phenomenon. This link between electromagnetism and light, confirmed by Heinrich Hertz (1857-1894)'s momentous experiment in 1887, was one of the greatest discoveries ever made in physics.

Final round

Maxwell left King's College and London in 1865, returning to his Scottish property at Glenlair. He nevertheless remained in contact with the scientific world, regularly travelling to Cambridge and even accepting the first ever post of professor of experimental physics there in 1871. It was in this capacity that he drew up the plans for the Cavendish Laboratory, officially opened on 16 June 1874.

Exploiting William Hamilton (1805-1865)'s quaternion number system, Maxwell published a more fully developed version of his partial differential equations in 1873, in his book *A Treatise on Electricity and Magnetism*. These famous Maxwell equations, which we now know in the vectorial form given to them by Oliver Heaviside (1850-1925) and Willard Gibbs (1839-1903), remain his crowning achievement.

In May 1879, in the middle of the Easter Term, Maxwell's health suddenly declined. He soldiered on, managing to give all his lectures, then returned to Glenlair with his wife Katherine, who was also in poor health. The next three months were marked by intense suffering, which he bore with fortitude and without sadness. When he returned to Cambridge in October, he could barely walk, and died on 5 November 1878, aged 48, having laid the physico-mathematical foundations for the revolution of relativity that was to take place in the early 20th century. ■

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