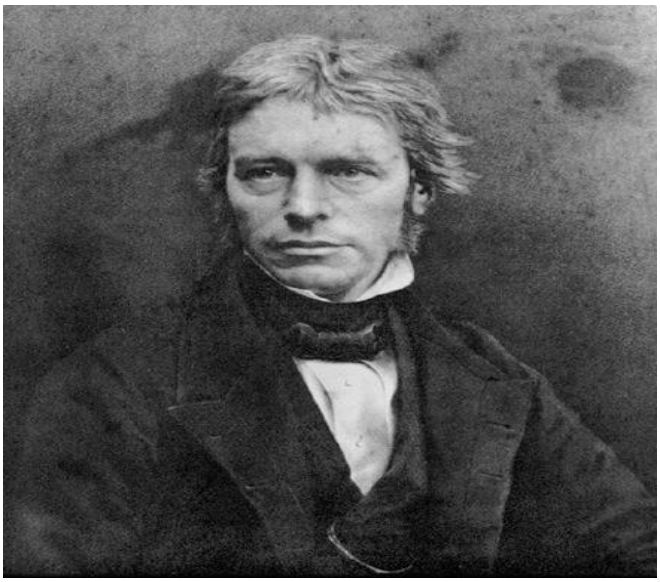
Last Days Beacon

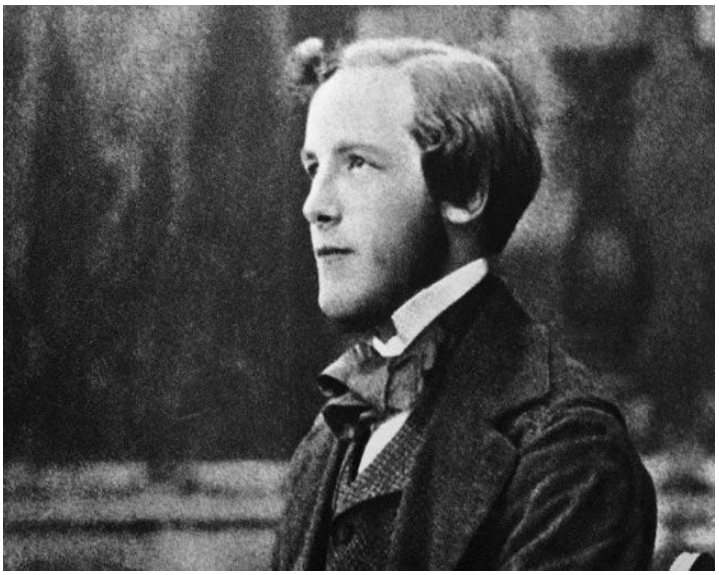
May 2020 – Vol. 5, No. 5 L-51

MICHAEL FARADAY & JAMES CLERK MAXWELL: THE TWO CHRISTIAN SCIENTISTS WHO PAVED THE WAY FOR ALBERT EINSTEIN AND $E=MC^2$

By Carol Rushton



Michael Faraday



James Clerk Maxwell

Albert Einstein is known around the world for being the genius who came up with the most famous equation in the entire world: $E=MC^2$. However, most people have never heard of Michael Faraday and James Clerk Maxwell, two Christians who were also scientists. Without their discoveries on the properties of electricity and light, Einstein, an agnostic Jew, would probably never have been able to come up with most of his five great 1905 papers, including the equation that would dazzle the world.

While Einstein revered them and had pictures of them on the walls of his study, Faraday and Maxwell have largely been forgotten outside the scientific community. Their findings would provide the foundation Einstein needed to prove his theories on the atom, light, time, and space. In spite of their vastly different backgrounds, Faraday and Maxwell were the men who would revolutionize science and prepare the way for Einstein and the modern world we know now.

Faraday's Impoverished Beginnings

In the early1800s, in social-status-conscious England, no one would ever have guessed that

the son of an impoverished, sickly blacksmith would one day become one of the leading scientists in the world. You may not realize it, but the car you drive to work, the plane you fly in to take you to faraway places, and the microwave you use to cook your food are all due to Michael Faraday.

Faraday was born in 1791 in one of the poorer neighborhoods of London. Faraday's father was ill for much of his adult life and could not properly provide for his family most of the time. The Faraday children often went to bed hungry. Michael learned to read and write and do simple math, but because of the family's destitute circumstances, was not able to continue his education beyond the basics.

One thing the Faraday family had in abundance was their strong Christian faith. The Faradays belonged to a small Christian body called the Sandemanians. According to David Bodanis, author of *$E=MC^2$: A Biography of the World's Most Famous Equation*, the Sandemanians were "a very gentle, decent group. They believed that under the whole surface of reality everything was created by God in a unified way, that if you opened up one little part of it, you could see how everything was connected." This desire to understand the universe God made was a driving force behind Michael Faraday's later success as a scientist.

In 1804, Faraday was hired by a bookbinder to run errands. Faraday must have impressed this man who, a year later, agreed to accept the 14-year-old as an apprentice for the next seven years. Faraday should have been overjoyed. He would be escaping his father's trade as a blacksmith and would be learning a skill that would help him escape the grinding poverty he had been brought up in and provide him with a modest living.

Although his employer praised Faraday for being a model employee, Faraday hated his job as a bookbinder. The only thing Faraday could see that benefited him was his boss' indulgence in allowing him to read any books that were bound and printed at the shop. Faraday read everything he could get his hands on, being especially attracted to books and articles about science. Faraday devoted any extra money he had, which wasn't much, to buy crude supplies to duplicate the experiments he read about.

Faraday was frustrated in his desire to break free from what he saw as a bleak future of toil and sweat. He longed for a career in science, but in early 19th century Europe, the only way anyone could become a scientist was if they had the wealth and social status to be able to study at one of the leading universities in Europe, something far beyond Faraday's reach. It must have seemed to Faraday that his ambition would never be anything but a pipedream.

However, Faraday's life was about to change in a very dramatic way. In 1812, Faraday had made an impression on one of his employer's customers, who gave Faraday tickets to four lectures at the Royal Institution by one of the preeminent chemists and scientists of the day, Sir Humphry Davy.

Davy had cemented his work as a chemist through his discoveries of various chemicals, including chlorine, as well as writing books about his chemical experiments. These led to his acceptance as a lecturer at Great Britain's Royal Institution in 1801 and a fellow of the Royal Society in 1803, eventually becoming its president in 1820. Davy was also a showman; his dramatic flair for presenting lectures and experiments drew large crowds. However, his penchant for nitrous oxide, known more commonly as laughing gas, almost overshadowed his other accomplishments.

"Davy was an absolutely first-rate scientist. However, many will come to say that his greatest discovery is Michael Faraday," S. James Gates, Jr., physicist, University of Maryland (Nova, "Einstein's Big Idea," 2005, PBS, https://www.youtube.com/watch?v=fyn1I-viYPw, accessed March 31, 2020).

Lectures at the Royal Institution were reserved for the "upper classes." Normally, they would have been off limits to someone of Faraday's social status. But Faraday was not going to let that stand in the way of gleaning every bit of knowledge Davy imparted through his lectures. Faraday absorbed every word from Davy's mouth like a sponge, inspiring Faraday to conduct more experiments on electricity in his homemade laboratory.

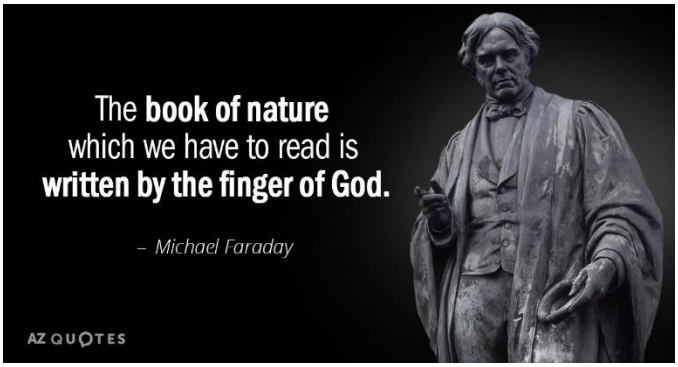
His days of apprentice nearing their end, Faraday was desperate to avoid the drudgery of a bookbinder. In what can only be seen as a humiliating act, he sent a letter to Joseph Banks, president of the Royal Society, pleading for a science position. Banks spurned Faraday with an equally demeaning response: "The letter required no answer" (Alan Hirshfeld, *The Electric Life of Michael Faraday*, 2006, Raincoast Books, pg. 22).

Having no choice, Faraday had to start his official job as a bookbinder. The man he worked for demanded Faraday channel all his energies and time into his job, leaving Faraday with no time and energy for anything else, including pursuing his love of science and experimentation.

Shortly after this, Humphry Davy injured one of his eyes while conducting an experiment. Mr. Dance, the customer who had given Faraday tickets to Davy's lecture series, recommended Faraday to Davy. While his assistant position to Davy only lasted a few days until he recovered his sight, it eventually led to something more permanent.

When the temporary position with Davy ended, Faraday took his detailed notes from Davy's lectures and turned them into a book to present to his idol. He sent Davy the book along with a letter, again asking for a permanent position. Davy couldn't offer Faraday anything at the time but that would soon change.

Despairing he would never have a career in science, Faraday resumed his work as a bookbinder. Even his employer's offer to bequeath the business to him did not excite Faraday. Thankfully for Faraday and us, God had other plans. When Davy sent Faraday word in1813 that one of his assistant's had been fired for fighting and offered him a job, Faraday never looked back. It wasn't much of a position – he would actually be nothing more than a janitor, living in the tiny attic at the Institution. The only thing Faraday requested was permission to use the equipment at the Royal Institution for his own experiments. As humbling as it was, Faraday could now embark on the journey that would not only change his life but the world.



The Experiment of the Century

It didn't take Faraday long to find a way of becoming more than just a janitor at the Royal Institution. Within a week, Faraday was helping Davy with his experiments. "I am constantly engaged in observing the works of Nature and tracing the manner in which she directs the arrangement and order of the world," Faraday excitedly wrote to relatives (Hirshfeld, 38).

Faraday was not only Davy's assistant; he helped others at the Royal Institution with their experiments as well. Now able to freely attend the Institution's lectures, Faraday not only increased his knowledge of science and chemistry, he studied every detail of each lecture, down to even the lighting, as well as noting the delivery of the lecturers. Nothing escaped him. This attention to detail would serve Faraday well when he started giving his own lectures years later.

Faraday became indispensable to Davy. As Davy and his wife travelled throughout Europe, he would ship various samples of items to Faraday for testing and research. Faraday became known to other chemists and scientists for his precise, careful, and detailed experiments, winning high praise from Davy and others. In 1816, Faraday had his first research paper published - pretty heady stuff for the son of a blacksmith. Faraday was humble as usual, later describing this time as "when my fear was greater than my confidence, and both far greater than my knowledge" (Hirshfeld, 61).

As Faraday's reputation grew, so did his influence outside the scientific world. He started receiving requests from private businesses and the British government to work on various projects, which helped him financially. Along with his ever-increasing duties at the Royal Institution, and his fledging beginnings as a lecturer at the City Philosophical Society, Faraday was a very busy young man.

1821 was a very pivotal year for Faraday. He married Sarah Barnard, a member of the small Sandemanian church he attended; he was appointed Superintendent of the House at the Royal Institution, making him responsible for all the buildings owned by the Institution and their contents; and last, but certainly not least, he became aware of findings by Hans Christian Oersted concerning the effect electricity had on a compass.

The battery had recently been invented in 1800. Before being hired by Davy, Faraday had constructed crude batteries in his makeshift home lab, so he understood the principle of electricity flowing from a battery through a wire.

"The academic establishment at the time thought that electricity was . . . like a fluid flowing through a pipe, pushing its way along. But in 1821, a Danish researcher showed that when you pass an electrical current through a wire and place a compass near it, it (electricity) deflects the needle [of the compass] at right angles," (S. James Gates, Jr., physicist, University of Maryland, Nova, "Einstein's Big Idea," 2005, PBS, https://www.youtube.com/watch?v=fyn1I-viYPw, accessed March 31, 2020).

No one understood why – until Faraday.

"Faraday was different from anybody else. He had a flair for understanding his experiments, for understanding what was really going on inside them . . . What everyone else at the time had been taught was that forces traveled in straight lines. Faraday was different. Faraday imagined that invisible lines of force flowed around an electric wire. And then he imagined that a magnet had similar lines emerging from it, and that those lines get caught up in this flow. It was a bit like a flag in a wind" (David Bodanis, Nova, "Einstein's Big Idea," 2005, PBS, https://www.youtube.com/watch?v=fyn1I-viYPw, accessed March 31, 2020).

Faraday believed that the electrical current passing from a battery through a wire emitted an electrical force of some kind that was invisible to people but that was affecting the magnetized needle of the compass. Today we know this as a magnetic field, but in the early 1800s it baffled scientists. In order to prove his theory, Faraday went one step beyond everyone else: He wanted to know if he could use the electricity flowing from a battery to move a wire around a magnet partially submerged in mercury. You can see a drawing of the apparatus Faraday used to conduct the experiment at the 14:12 mark of a video on YouTube, "Michael Faraday: The Father of Electricity" (https://www.youtube.com/watch?v=Aesm5mXkoww, accessed April 1, 2020). The normally unflappable Faraday could not contain his excitement about the success of his experiment.

Physicist S. James Gates, Jr. at the University of Maryland explains the meaning of this

momentous development. “This is the experiment of the century. It’s the invention of the electric motor. Scale up the magnets and the wires, make them really big. Attach heavy weights to them, and they’ll be dragged along. But almost more importantly, he’s inventing a new kind of physics here” (“Nova, “Einstein’s Big Idea,” 2005, PBS, https://www.youtube.com/watch?v=fyn1l-viYPw, accessed March 31, 2020).

Not everyone was thrilled with Faraday’s discovery. Davy had recently been appointed president of the Royal Society. When Faraday’s results were published in the *Quarterly Journal of Science* on October 1, 1821, Davy attacked Faraday, accusing him of stealing this idea from William Wollaston, a very distinguished British scientist, who had done similar work but had failed in his experiments where Faraday had succeeded.

Wollaston assured Faraday he was not upset, basically telling him in today’s terms that everyone was making a mountain out of a mole hill. But Davy would not apologize to Faraday or let the matter drop. In 1823, one of Faraday’s friends nominated him for membership in the Royal Society with the support of twenty of the members, including William Wollaston! Davy viewed this as a slap in the face and demanded Faraday retract his nomination.

Faraday explained to Davy that his friends had nominated him so he couldn’t withdraw. In 1824, Faraday was elected to the Royal Society – with only one vote against him.

Although Davy was responsible in 1825 for Faraday’s new position as director of the laboratory at the Royal Institution, the rift between the two men never healed. Davy became ill and had to resign as president of the Royal Society in 1826, eventually dying in1829.

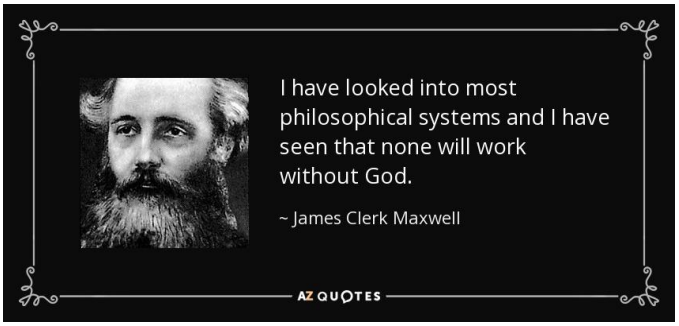
The “experiment of the century” would have been a great life’s achievement for any scientist. But Faraday did not rest on his laurels. He went on to discover benzene, coined the words *cathode*, *ion*, *anode*, *electrode*, *electrolyte*, *electrolysis*, and *force field* from his further experiments on electricity, discovered electromagnetic induction, and published numerous papers about his experiments, becoming one of the most famous scientists of the day. His accomplishments are too numerous to mention. Faraday was recognized with many awards; Oxford bestowed on him an honorary degree. His admirers ranged from Charles Dickens to Queen Victoria. This son of a poor blacksmith eventually was christened with the title of Professor Faraday.

The Royal Institution was deeply in debt when Faraday became the director, so he started weekly meetings with wealthy, potential donors about the scientific research being conducted at the Institution. These meetings became so popular that Faraday turned them into the Friday Evening Discourses, inviting guest lecturers that attracted hundreds and was the “in” place to be on a Friday night in London. Faraday started science lectures for children during the Christmas season which he always made fun, entertaining, and educational, exposing hundreds of English youngsters to a subject they would normally not have found accessible. Both lecture series Faraday started in the 1820s still continue at the Royal Institution today.

Faraday was a self-confessed workaholic. He relished his work but his responsibilities at the Royal Institution, his private experiments and research, papers, lectures, along with his work for private businesses and government institutions contributed to an exceptionally frantic lifestyle. Faraday’s health suffered at the dizzying pace and heavy workload, leading to periods of migraine headaches when he couldn’t work at all. His wife would force Faraday to take a break from his work for months at a time in order to recover. As he got older, his bouts with headaches became more frequent and started to affect his memory, not good for a scientist. Eventually, these periods

of illness broke his health for good and forced him into a very reluctant retirement in 1862 at the age of 71.

Even though the experiments of Faraday and others on electricity, light, and magnetism were revolutionary in their day, no one, including scientists, was sure what light actually was. Based on his experiments, Faraday believed that light was an electromagnetic wave. But Faraday's lack of education hindered him. Although he was a great researcher and experimenter, he was woefully deficient in the mathematical skills he needed to prove his theory. Fortunately for Faraday, one man came along to verify his conjecture.



JAMES CLERK MAXWELL COMES TO FARADAY'S RESCUE

At first glance, you would think Michael Faraday and James Clerk Maxwell would not have much in common. Maxwell's early life was as different from Faraday's as you can imagine. Maxwell spent his childhood at his family's country estate, Glenlair, in southwest Scotland. Some of his forebears were very distinguished; they included a member of the Royal Society and a geologist. Maxwell's family lived the life of the well-to-do country gentry which included regular social events such as dances, dinners, and fairs. Maxwell's family recognized his exceptional intelligence, patiently putting up with his toddler demands to know how everything worked – in exacting detail. In fact, Maxwell showed his proclivity for science as a small child, figuring out how to use a tin plate to reflect sunlight.

One thing both Faraday and Maxwell had in common was their family's staunch faith in God. According to a recent biography of Maxwell, "Every day the household, including servants, met for prayers and every Sunday they went to Parton church, five miles to the west" (Basil Mahon, *The Man Who Changed Everything: The Life of James Clerk Maxwell*, 2003, John Wiley & Sons, Ltd, West Sussex, England, pg. 5).

Tragedy struck the family when Maxwell was eight years old. Until that time Maxwell had been tutored by his mother. But when she died of cancer, Maxwell's father hired a teenage tutor for him, who tried to force Maxwell to learn by rote. Maxwell was bright and intelligent but rebelled; this educational experience ended in disaster, and the tutor was dismissed.

Some of their relatives convinced Maxwell's father to enroll him in a proper school in Edinburgh. Maxwell would live with them during the school months and return to Glenlair for holidays. His father dreaded the time away from his only child but decided this was the best thing for his son. Maxwell had a very difficult time. Coming from the country, he didn't fit in with his city classmates. His accent and clothes were different, and his schoolmates tortured him unsparingly.

Maxwell eventually found his footing and astonished his classmates with his amazing math skills, gaining their respect. By 14, the Royal Society was publishing his scientific findings. His father finally bowed to the obvious and allowed Maxwell to pursue a college degree in science (not an actual paying profession at the time) instead of law.

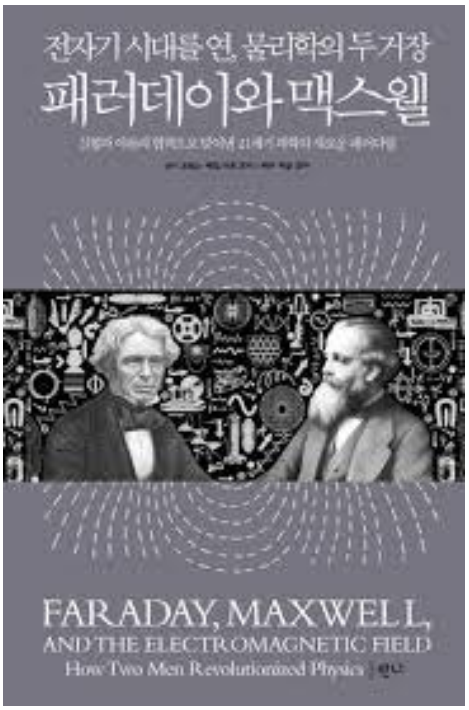
Maxwell was off to the races and never stopped. Just like Faraday, his many accomplishments and how they changed our world are too many to list. Maxwell's equations on a number of scientific topics, some of which were not understood at the time, paved the way for advances in engineering, topology, control systems, cybernetics, modern vector analysis,

modern communications and computers, statistical mechanics, rarefied gas dynamics and optics, just to name a few. His discoveries on color brought us color photos, color television, and more (if you have used Photoshop or its equivalents, you have used Maxwell's color wheel – r(red), g(green), b(blue)). Maxwell was the first to propose that Saturn's rings were made out of many separate particles, proven by Voyager I and II in the 1980s. He also came up with the term "relativity," for which most credit Einstein.

But it is Maxwell's equations on electricity, magnetism, and Faraday's lines of force that he is most well-known for. Faraday was ridiculed by the scientific community for his belief that "invisible lines of force" emanated from electricity. But not Maxwell. He saw beyond Faraday's crude drawings to their scientific potential. "As I proceeded with the study of Faraday, I perceived that his method . . . was also a mathematical one, though not exhibited in the conventional form of mathematical symbols" (David Bodanis, *$E=MC^2$: A Biography of the World's Most Famous Equation*, 2000, Berkley Books, New York, pg. 47, from Maxwell's preface in his *Treatise on Electricity and Magnetism*, 1873).

In three separate publications, in 1855, 1861, and 1865, building on and improving his equations, Maxwell mathematically proved that Faraday's "lines of force" were indeed true. After the publication of the first 1855 paper, Faraday sent Maxwell a letter of appreciation and their resulting correspondence developed into a close friendship when they were finally able to meet after Maxwell moved to London in 1860 to begin a professorship at King's College. Maxwell's equations also proved that Faraday was right in another area: magnetism and electricity are only achieved at 670 million miles per hour, the speed of light. Light is an electromagnetic wave, just as Faraday had claimed.

Incredibly, scientists still rejected Faraday's and now Maxwell's findings. It would take years before they would finally be accepted. Maxwell's equations on the electromagnetic theory of light would lead to the development of radio, radar, television, satellites, and so much more. Maxwell's electromagnetic theory of light is considered one of the most important scientific discoveries of all time.



Understanding Faraday and Maxwell: Both Christians and Scientists

It is annoying the way atheistic scientists today talk about Faraday and Maxwell. They claim that Faraday and Maxwell never allowed their religious faith to interfere with their scientific work. These scientists simply do not understand that Faraday and Maxwell would never conceive of a world in which scientists would try to use science to disprove God and the Bible. Faraday and Maxwell believed that science and Christianity were not in conflict with one another, that they actually complemented each other. Science would always confirm the existence of God and prove that God created this universe and everything in it.

Einstein called Faraday's invisible lines of force "the great revolution." Einstein said, "One scientific epoch ended and another began with

James Clerk Maxwell." Faraday and Maxwell were very brilliant men, ahead of their time. Yet both were described by their family, friends, and colleagues as generous, warm, kind, and compassionate, always caring about others more than themselves. It is a tragedy that Faraday and Maxwell have been largely forgotten by the world. They certainly have not been forgotten about by the Lord.

> *No matter what you look at, if you look at it closely enough, you are involved in the entire universe* – Michael Faraday

For those who want to learn more about Faraday, Maxwell, Einstein, and $E=MC^2$, I recommend the following:

"Einstein's Big Idea," PBS documentary, YouTube.com

$E=MC^2$: A Biography of the World's Most Famous Equation by David Bodanis.

The Electric Life of Michael Faraday, by Alan Hirshfeld.

The Man Who Changed Everything: The Life of James Clerk Maxwell by Basil Mahon

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