Electricity and Magnetism: History

The Ancients.

The effects of Magnetism and Electrostatics were known from ancient times; Thales of Miletus discussed the lodestone, which he believed contained a soul, and ancient Greeks knew that amber rods, rubbed with fur, developed a charge. In the early 1200's, lodestones were being used as compasses (they always point to the magnetic North). The development of understanding was speeded up by the establishment of the scientific method (via Mechanics).

William Gilbert (1540-1603)

Gilbert has been called "the Galileo of magnetism". Apparently his duties as personal physician to Queen Elizabeth I of England allowed him time to study several scientific questions. He was the first to make a truly systematic study of magnetism, summarized in his famous treatise, De Magnete, he concluded that each magnet has two poles, that forces between poles can be attractive or repulsive, and suggested that the earth is a large magnet. He studied electricity and its difference from magnetism, developing a list of substances which he found became charged upon rubbing. He also demonstrated that the earth spins about its own axis (in opposition to Brahe's views).

Charles François du Fay (1698-1739)

superintendent of the gardens of the King of France, discovered that rubbing two different objects together produced two types of electric charge. He adhered to the view that matter contained two types of fluid, normally in exact balance; when two
bodies were rubbed together, however, this balance was disturbed, and each body acquired an excess of one or the other type of fluid.

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**Benjamin Franklin (1706-1790)**

A Freemason, a printer, an inventor, a politician, a statesman and a scientist, Benjamin Franklin was one of the several extraordinary men who emerged in America around the time of its struggle from independence from England. Although he initially wished to keep America an English colony his time as ambassador to France during the American war of independence changed his mind and he was one of the Founding Fathers of the United States, and a major contributor to the Declaration of Independence; "we hold these truths to be self-evident, that all men are created equal" is largely his work. He was much loved in France as a "son of Nature", and when he died the Assembly Générale closed for three days. He was a strong proponent of basic science - "of what use is a newborn baby?" he is rumored to have asked of a skeptic - and he was particularly fascinated by electricity. He did a series of very dangerous experiments which involved flying a kite into thunder clouds; several of his imitators were killed. He invented the lightning rod, pointing out that a pointed end would be more valuable than a rounded one. He was one of the first to propose the "one fluid" theory of what gets rubbed off when bodies charge by friction; this theory proposed that only one of the charges moves. Unfortunately for generations of students, his chosen direction of flow was chosen to be opposite to that which we now call electron flow.

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**Charles August Coulomb (1763-1806)**

Coulomb was born in Angouleme, France. As a military engineer, he constructed the Bourbon fort in Martinique, where he worked for 9 years. His health deteriorated and, at the beginning of the French revolution, he returned to France to retire. He invented the torsion balance, which allowed him to study the very small forces between electrostatically charged objects. He showed that the force between two charges is proportional to the size of the charge, and inversely to the square of the distance between them.

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**Alessandro Volta (1745-1827)**

Invented the battery, using layers of zinc and copper with wet pasteboard between them (more modern ordinary commercial batteries consist of a shell of zinc - the cathode - which holds a moist paste of ammonium chloride - the electrolyte - with a carbon rod - the anode - inserted in the middle. There are now many different combinations, such as mercury, Nickel-Cadmium, etc.). Moving charges (electric currents) could now be studied. He also realized that the "galvanic" effects (so called after Galvani, who, in 1780, noticed that frog's legs responded by contracting when given an electric impulse) arose from the fact that nerves conduct electricity.
**Hans Christian Oersted. (1777-1851)**

In 1820, during one of his advanced lectures at the University of Copenhagen, this Danish physicist made the fundamental discovery concerning the connection between magnetism and electricity. After studying the effect for three months using a battery he had constructed, he announced his discovery in a paper written in Latin, following a time-honoured tradition. By connecting his copper-zinc batteries to a straight section of conducting wire, he demonstrated the deflection of a magnet aligned parallel to the wire. Thus he showed that uniformly moving charges produce constant magnetic fields; as a corollary, we can see that *accelerating charges produce changing magnetic fields*. André-Marie Ampère (1775-1836) quickly repeated Oersted's experiment, and formulated them mathematically. Ampère also showed that wires carrying electric currents exert forces on each other, thus demonstrating that magnetic fields exert forces on electric currents.

**Michael Faraday**

The son of a blacksmith, Michael Faraday was almost entirely self-taught. In 1812 he attended the lectures of Sir Humphry Davy, director of the Royal Institution. He submitted his notes of these lectures to Davy with a request for a position, however menial. Davy took him under his wing at the Institution where he remained for the rest of his scientific career, eventually ascending to the post of director. Davy's support enabled him to pursue a most productive series of experimental investigations, initially in Chemistry, and then, for 40 years, in Physics. To him we owe the concept of field and field lines. His name is also associated with electromagnetic induction; spurred by Oersted's realization that electricity produces magnetism, he successfully showed the converse, that magnetism produces electricity. After a series of investigations spanning over six years, he discovered that a *moving* magnet induces electric current in a neighboring wire.

**Maxwell (1831-1879)**

Achieved a synthesis of all the experimentally observed data on electricity and magnetism in his four equations. By a brilliant insight he saw the need for an extra term in one of the equations; its existence led to the prediction of electro-magnetic waves, which were discovered in 1895 by Hertz, and exploited by Marconi in 1896. In a sense Maxwell's work was the final capstone in classical physics. Indeed, at the end of the 19th century one physicist proclaimed the impending death of physics; since all fundamental physical phenomena were now understood, physicists could leave the working out of the details and the mopping up of a few remaining but trivial questions to lesser scientists, such as chemists and engineers. How wrong he was! It is one of the great ironies of science that the very experiments performed by Hertz, triumphantly verifying Maxwell's prediction using the photo-electric effect, turned out to have no obvious classical explanation. The exploration of this question was to lead to the first assault on the classical view, and a radical and extraordinary shift in our understanding of Nature. On to quantum mechanics!