Deductive Reasoning Prevails

Another deductive reasoner was James Clerk Maxwell, who had brought classical physics to a close toward the end of the 19th century with his 1873 summation *A Treatise on Electricity and Magnetism.* He had completed the development of this branch of theory with his electromagnetic field equations, now referred to as *Maxwell's Equations*. Maxwell revered Michael Faraday for the ingenuity of his historic experiments in revealing the deep subtleties of electromagnetism. Maxwell was inherently a deductive researcher and he also appreciated this trait in Faraday for his combination of conceptual imagination and systematically allowing for any possibility in the search for a solution. He also had a high opinion of the work of André-Marie Ampère (1775-1836) and called him the "Newton of electricity," however, Ampère leaned toward the inductive approach in his research. Despite the greatness of both Faraday and Ampère, Maxwell noted the difference in their approaches and presentation of results. Maxwell summarized in Part IV, Chapter III of [560]:

> *The method of Ampère, however, though cast into an inductive form, does not allow us to trace the formation of the ideas, which guided it. We can scarcely believe that Ampère really discovered the law of action by means of the experiments, which he describes. We are led to suspect, what, indeed, he tells us himself, that he discovered the law by some process which he has not shown us, and that when he had afterwards built up a perfect demonstration, he removed all traces of the scaffolding by which he had raised it.*
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> *Faraday, on the other hand, shews us his unsuccessful as well as his successful experiments, and his crude ideas as well as his developed ones, and the reader, however inferior to him in inductive power, feels sympathy even more than admiration, and is tempted to believe that, if he had the opportunity, he too would be a discoverer.*

The reporting by Faraday of failures as well as successes in his experimental attempts is all too rare in scientific reporting, but it is an essential aspect of the deductive process. Faraday's law, the generation of an electromotive force in a coil due to a changing magnetic flux, is a fundamental result and is the working principle of electric motors, generators and transformers. Ampère had come close to discovering this law but without having Faraday's deductive thoroughness, he had ignored the crucial aspect of the changing magnetic flux and found no effect to his long-lasting regret.

On the hundredth anniversary of Maxwell's birth, Einstein described the deductive path Maxwell took in arriving at his celebrated equations, explaining that Maxwell began thinking in terms of mechanical models which would reproduce aspects of the known electrical and magnetic behaviors. But then he was able to extract the essence of these models, leaving behind what we now refer to as electric and magnetic fields described by differential equations [561],

> *If the idea of physical reality had ceased to be purely atomic, it still remained for the time being purely mechanistic; people still tried to explain all the events as the motion of inert masses; indeed, no other way of looking at things seemed conceivable. Then came the great change, which will be associated for all time with the names of Faraday, Maxwell, and Hertz. The lion's share in this revolution fell to Maxwell. He showed that the whole of what was then known about light and electromagnetic phenomena was expressed in his well-known double system of differential equations…Maxwell did, indeed try to explain, or justify, these equations by the intellectual construction of a mechanical model…But he made use of several constructions at the same time and took none of them really seriously, so that the equations alone appeared as the essential thing and the field strengths as the ultimate entities, not to be reduced to anything else.*
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> A. Einstein, Maxwell's Influence on the Evolution of the Idea of Physical Reality, p. 266, In: James Clerk Maxwell: A Commemorative Volume on the one hundredth anniversary of his birth, Cambridge University Press, Cambridge 1931.