ARTICLE II.

# THE DEVELOPMENT OF SCIENTIFIC THOUGHT IN THE NINETEENTH CENTURY.

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THE nineteenth century was prëeminently the century of science, as the eighteenth was the philosophical century,—the century of Voltaire and the Illumination. A thing of deep and delightful interest is the development of nineteenth-century scientific thought. But the nineteenth-century developments must be looked at in connection with the rise of modern science. Its rise was in our own country. One may very well claim to be heretical enough to dissent from the currently accepted view which makes Lord Bacon, in some sort, the father of all modern scientific achievements, and the pioneer of all scientific movement. Such a view stands in need of correction and serious modification. No doubt it was the merit of Bacon to have presaged and prophetically announced the new ideal and spirit of scientific advance, and to have given useful and healthy directions for the goal being attained. It was Bacon's great merit to have brought into view an empirical principle capable of general application. But his was the defect to have failed to carry out that principle to any fruitful or corporeal issue. He had not, in fact, the patience and the exactitude of a great scientific mind; and he really missed the goal to which he aspired, when it came to the working out of his great visions of reality in actual investigations. Indeed, the Baconian way of gathering facts first, and leaving theorizing to come afterwards, is too easily capable of proving a rather disastrously fallacious one for research of any sort. It would not be difficult to show how thinkers, early and late,—Aristotle, Hegel, and Tennyson, for examples,—have caught glimpses of really truer modes of thinking. It was Newton who, by his actual scientific patience and brilliant power, laid down the guiding lines of scientific principle, and gave these principles splendid application, so that they rested on sure and permanent basis. The law of universal gravitation associated with Newton in the seventeenth century and the "law of Watt" in the eighteenth, which determined the latent heat of steam condensation at different temperatures and pressures, bring us, in the briefest way, to the nineteenth century. It was the triumph of the nineteenth century to have made science no more a merely national thing, but something international—a European thing; one result of which is, that a truncated or disjointed view of the developments of its scientific thought can be avoided only by looking, not at British science alone, but at the developments of France, Germany, and Britain. This we shall do briefly in turn.

By the beginning of the nineteenth century, France had become the chosen home or metropolis of science. It had had, in the seventeenth century, its Descartes, great alike as philosopher and mathematician, in fact, a more original and powerful force in the way of actual contribution to science than Bacon. It is an exceedingly interesting fact that so many of the French philosophers were also eminent mathematicians. There were, for example, Descartes, Pascal, and Malebranche, in the seventeenth century; in the eighteenth, Fontenelle, D'Alembert and Condorcet; and in the nineteenth, Comte, Renouvier, and Cournot. Not a few of the modern sciences had their foundations in France, some of them under the influence of the strictly mathematical spirit. Of these latter were the science of crystallography and the famous theory of probabilities. Laplace, Lagrange, Legendre, and others were among the foremost exponents of the mathematical spirit. A significant incident of that time was the Emperor's sending for M. Laplace, after his great work on the theory of the heavens appeared, and asking how it was that the name of God did not appear in that great work; to which Laplace replied, *Sire, je n'ai pas besoin de cette hypothèse* ("Sire, I had no need of that hypothesis"). For it showed that already it was understood how science had, as science, its own work to do in the world without calling in the aid of divine action. Laplace was the first to give a great and broad setting forth of the ideas of Newton. Besides the independent footing gained for the mathematical sciences, an altogether new and sure foundation was laid for the science of chemistry by Lavoisier; while that rare exponent of the modern scientific spirit, Cuvier, introduced comparative anatomy and palæontology. As a result, the whole of nature became more completely grasped. Nothing seems, in our view, more striking in French scientific thought than the value set upon strictness of method. In fact, from the days of Descartes on to those of Comte, there has been a tendency in France to make method science itself. There have been constant aim and tendency towards deduction, but yet in such wise that room and play have been found for empiricism in method. The positive philosophy of Comte, it should be remembered, was far enough from giving its sanction to empiricism. Its demand was that observations be explained by theory and combined into a law. Its stress lay on the objectivity of truth.

When we turn to the scientific developments of Germany in the nineteenth century, we find that already the scientific bases had been there laid by men like Kepler, Leibnitz, and Euler.

Humboldt, with his vast attainments, did much to foster science. German equivalents of Laplace and Lagrange and Lavoisier and Cuvier, in France, easily suggest themselves in Gauss and Jacobi, in mathematics; Liebig and Wöhler, in chemistry; Schleiden and Schwann, in biology; Müller and Weber, in physiology, to mention no others. The scientific thought of Germany has been profoundly affected, on its mathematical and physical sides, by the philosophy of Kant, which has indelibly impressed the German intellect with the need for critical study of the principles of knowledge. The ideal of science has, in Germany, been particularly wide and high, and its pursuit has been sedulously cultivated for its own pure sake. Modern biological science has there had no greater representative than Du-Bois Reymond, who had Johannes Müller for his master. Du-Bois Reymond's work is not so widely known in this country as it deserves to be. The science of life, or physiology, ought not, he held, to be a pure morphology, or merely describe the functions of the organs, but ought to investigate the forces of the vital processes or the factors which render them possible. Such forces must not be different from those of chemistry and physics, which are governed by the laws of the conservation of energy and indestructibility of matter and movement. In other words, physiology should be nothing else than analytical mechanics of vital phenomena. Further, experiment and induction must, in respect of such methodical proceedings, take the place of abstract speculation. Du-Bois Reymond's intellect was of the pure rationalistic type, to which everything must be tabulated, analyzed, precisely valuated. An ideologist he was who would give a reason for everything by means of a few elementary conceptions. The mechanical view of the study of life was carried through until, in Du-Bois Reymond's own words, "the pale specter of a vital force could no more be seen." On higher matters, this great German physiologist held not only that consciousness cannot as yet be explained out of mechanism, but that it never will be so explained. For him *ignorabimus* was the word in this connection. Another German scientist whose work is inadequately appreciated amongst us is Helmholtz. Helmholtz was not only great as mathematician, physicist, and physiologist, but was a large and comprehensive spirit, to whom everything vital to the human spirit was of deep interest. Profoundly versed he also was in speculations rooted in the philosophy of Kant, and his investigations in the physiology and psychology of sense-perceptions were of great importance. He made noteworthy scientific advances in laying foundations for the branches of science known as physiological optics and musical acoustics. Associated his name remains with that of our own Lord Kelvin, in connection with the doctrine of the conservation of energy and the theory of vortex motions. In fine, we have in Helmholtz a rare and wonderful combination of intellectual powers of the first order. He was no votary of that blind worship of pure "fact," to which Du-Bois Reymond lent his great influence. Helmholtz thought that knowledge should be examined, its implicit elements analyzed and discovered, and the presuppositions which make it possible investigated. So differs he—for the better—from Du-Bois Reymond, to whom there was nothing *a priori* in knowledge.

The British developments in scientific thought were, at the beginning of the nineteenth century, associated with such great names as the Herschels, Priestley, Cavendish, Davy, Young, Dalton, Faraday, Brewster, Rowan Hamilton, Lyell, and others. Practically over the whole course of nineteenth-century thought, the influence of Dalton's atomic theory of matter has been felt, even though, after various modifying tendencies, it can hardly yet be said to have reached perfectly stable equilibrium. The same thing is true of the influence of Dr. Thomas Young's undulatory theory of light, with the existence of ether. British scientific thought was too little an organized product—too much the result of scientific individualism. In the second half of the century, natural philosophy was as good as revolutionized under Lord Kelvin and the late Clerk Maxwell. Since 1860, the influence of Darwin has been particularly felt. Great was Darwin's caution of intellect, and enormous the mass of facts on which he rested his great induction—the law of natural selection. Its influence was far-reaching, and statical pre-Darwinian philosophies were almost immediately affected, in their powerlessness to appreciate development. It was felt that neither Comte, nor Hegel, nor Buckle, nor Mill, had done justice by the dynamic and kinetic elements of actual Nature. The full philosophic conception of evolution as a cosmical process has been set forth by Spencer with the varied splendor of a great cosmical law. In fact, the second half of the century was concerned with these three great scientific ideas: (1) Darwin's theory of descent, or the principle of evolution; (2) the law of the conservation of energy, associated with the names of Joule, Thomson, and Helmholtz; and (3) Faraday's conception of electrical phenomena, or the principles of electromagnetic induction and electrolysis. For the scientific man who is also a philosopher, the principles and canons of scientific thought have an interest beyond that of the sciences themselves. These have not lacked expounders in Sir John Herschel, Comte, Mill, Whewell, and the late Professor Jevons. Almost every leading idea in the scientific thought of the century had been long before anticipated, but such precise statement and correct analysis of them had not before been given.

And an altogether new stimulus was given to thought, in the latter half of the century, by the doctrine of the persistence of matter and of force, and the enunciation of the law of natural selection. We have seen that the fundamental conception of Du-Bois Reymond was, that natural causes can be no other than mechanical causes. Of the mechanical interpretation of reality, the complement is found in the theory of evolution. Particular sciences have shown themselves, from their methods of procedure, unable to find a solution for many of the problems raised, and the need has grown more manifest that scientific thought become more deeply penetrated with the method and fundamental conceptions of critical philosophy. In fact, it is just such interpenetration which gives present-day scientific speculation whatever tendencies it has of a more vital character. It ought never to be forgotten that it is only the *how* of the universe which such scientific thought can give us, not its *what.* But that is precisely what both Huxleyan teaching and Spencerian doctrine have failed to understand. It was the merit of Huxley to feel the need of a theory of knowledge, but he did not have a clear consciousness of his own theory of the subject. To him truth easily became the private property of the scientific method; so forgetting that, though all knowledge is capable of scientific treatment, such treatment is by no means exhaustive of reality. A philosophy of reality is still necessary. For science has not the inner life and wealth of concrete reality for its aim and object. Huxley thought we can only understand spirit, if we view it as matter; so making the astonishing mistake of forgetting that the only thing of which we are certain, is spirit. So, too, Spencer failed, in his own way, to distinguish sufficiently between theory of knowledge and metaphysic; pouring, in fact, a metaphysical signification into the former. Spencer's criterion is a more subjective one than Huxley's: the former speaks of "assuring ourselves," while the latter craves "demonstrability." Both in England and in Germany scientific thought, in the last quarter of the nineteenth century, showed an increasing sense of the importance of these questions of epistemology, and the last word is far from having been said upon the subject. Not a little of the stimulus to thought in this direction has been given by Helmholtz, Professor Ostwald, St. George Mivart, and others. The latest scientific thought of our time seems to require always more the abandonment of the naturalistic method, and to call for some interpretation of reality such as may be found in some form of spiritualistic monism.