ditions under which physical changes regularly and periodically manifest themselves; and must conduct to the thoughtful consideration of the results yielded by empirical observation, but not to "a contemplation of the universe based on speculative deductions and development of thought alone, or to a theory of absolute unity independent of experience." We are, I here repeat, far distant from the period when it was thought possible to concentrate all sensuous perceptions into the unity of one sole idea of nature. The true path was indicated upward of a century before Lord Bacon's time, by Leonardo da Vinci, in these few words: "Cominciare dall' esperienza e per mezzo di questa scoprirne la ragione."* "Commence by experience, and by means of this discover the reason." In many groups of phenomena we must still content ourselves with the recognition of empirical laws; but the highest and more rarely attained aim of all natural inquiry must ever be the discovery of their *causal connection*.† The most satisfactory and distinct evidence will always appear where the laws of phenomena admit of being referred to mathematical principles of explanation. Physical cosmography constitutes merely in some of its parts a cosmology. The two expressions can not yet be regarded as identical. The great and solemn spirit that pervades the intellectual

* *Op. cit.*, vol. ii. p. 283.

† In the Introductory Observations, in *Cosmos*, vol. i., p. 50, it should not have been generally stated that "the ultimate object of the experimental sciences is to discover laws, and to trace their progressive generalization." The clause "in many kinds of phenomena" should have been added. The caution with which I have expressed myself in the second volume of this work (p. 313), on the relation borne by Newton to Kepler, can not, I think, leave a doubt that I clearly distinguish between the discovery and interpretation of natural laws, *i. e.*, the explanation of phenomena. I there said of Kepler: "The rich abundance of accurate observations furnished by Tycho Brahe, the zealous opponent of the Copernican system, laid the foundation for the discovery of those eternal laws of the planetary movements which prepared imperishable renown for the name of Kepler, and which, interpreted by Newton, and proved to be *theoretically* and *necessarily* true, have been transferred into the bright and glorious domain of thought, as *the intellectual recognition of nature*." Of Newton I said (p. 351): "We close it [the great epoch of Galileo, Kepler, Newton, and Leibnitz] with the figure of the earth as it was then recognized from *theoretical* conclusions. Newton was enabled to give an explanation of the system of the universe, because he succeeded in discovering the force from whose action the laws of Kepler necessarily result." Compare on this subject ("On Laws and Causes") the admirable remarks in Sir John Herschel's address at the fifteenth meeting of the British Association at Cambridge, 1845, p. xlii.; and *Edinb. Rev.*, vol. 87, 1848, p. 180–183.