natural history of the phenomena, collect and tabulate all observations which bear on them, notice which phenomena are related in such a way as to vary together, and then, by a merely mechanical process of exclusion, we discover the cause of any given phenomenon. As a corrective of the medieval philosophy Bacon’s work was of the greatest value in the history of thought, and, from this point of view, it is perhaps but a small drawback that scientific discovery is seldom or never made by the pure Baconian method. The multitude of phenomena are too great for any subject to be attacked with success without the aid of hypothesis framed by the use of the scientific imagination. Facts are collected to prove or disprove the consequences deduced from the hypothesis, and thus the number of facts to be examined becomes manageable.

Even while Bacon was philosophizing, the true method was being used by Galileo Galilei (1564-1642) to found the science of dynamics. We have seen how the Aristotelians held the belief that every body sought its natural place, the place of heavy bodies being below and that of light ones above. Innate qualities of heaviness and lightness were thus invoked to explain why some things fell, and others, in similar circumstances, rose. Galileo, rightly rejecting the whole current point of view, set himself to examine not why, but how, things fell. This change of attitude was in itself one of his great achievements. Now a falling body starts from rest and falls with a speed which is increasing constantly. Galileo sought to find the law of increase. To isolate the real law out of all possible laws he made a guess at a simple law which seemed likely to be true. He assumed that the speed acquired is proportional to the distance fallen through. But, working out the consequences of this hypothesis, he soon convinced himself that it involved a contradiction. He abandoned the hypothesis and made another. He supposed that the speed was proportional to the time of fall. Again he deduced mathematically the consequences of this new hypothesis, and, finding no incon­sistencies, put some of his deductions to the test of experiment, and verified their accuracy. Thus Galileo proved mathemati­cally that, if the speed of fall is proportional to the time from the moment of starting, the space traversed by a falling body must be proportional to the square of the time of fall. To verify this result experimentally, Galileo convinced himself that a body falling down an inclined plane acquired a speed which is the same as that it would have attained in falling through the same vertical height. He was able therefore to use a slow fall down a plane for his experiments instead of the unmanageably rapid course of a body falling freely. Nor was this all. From this stage to the investigation another con­sequence of his results was found to spring. A ball after running down an inclined plane of a certain height will run up another plane of the same height irrespective of its inclination—that is, if friction be small. The second plane may be made very long, but still, if its final height be the same, the ball will reach its end. Hence it is the height that matters; none of the speed of the ball is destroyed unless it rises. If the second plane be made horizontal, the ball will thus run on for ever unless stopped by friction or some other applied force. This fundamental result, put into definite words by Newton, is known as the first law of motion, and is the foundation of the whole science of dynamics. In Galileo’s day it was an entirely new conception. It has been assumed that every motion required some cause or force to maintain it. Hence arose the need of hypothetical vortices to maintain planetary movements, and similar com­plications in astronomy and mechanics. But it now became evident that it was not the continuous motion of the planets which needed explanation, but the constant deflection of that motion from the straight path it would hold if no applied force

were in action. The way was open for Newton.

Sir Isaac Newton (1642-1727) proved mathematically that the observed motion of the planets about the sun could be explained, and explained only, by the supposition that the sun exerted a force on each planet proportional inversely to the square of its distance from the planet. But

the earth, at any rate, does attract bodies on or near its surface, the phenomenon being the familiar but mysterious gravity. Is this force competent to account for the motion of the moon round the earth? On the assumption of the law of inverse squares, Newton calculated what the known force of gravity would become at the distance of the moon. Owing to faulty data, his first result indicated that the force would be too great, and Newton put aside his calculations. Six years later a new determination of the size of the earth gave him a new basis for calculation, and, in an excitement so great that he could hardly see his figures, Newton found that the fall of a stone to the earth and the sweep of the moon in her orbit were due to the same cause. The mechanism by means of which the force is exerted remained unrevealed to Newton, and has baffled all inquirers since his day, but the discovery that all the movements of the heavens could be described by one simple physical law, represents the greatest achievement in the history of science.

Newton brought the existing state of the solar system within the cognizance of known dynamical principles, and the logical extension of such principles to explain the origin of that system was made by the speculations of Pierre Simon, marquis de Laplace (1749-1827), and developed by those who followed him. They imagined a primitive state of nebu- losity from which, by the action of known dynamical processes, the sun and planets would be evolved.

These speculations, isolated at first, coalesced with the more detailed conclusions of geology during the 19th century. The earlier conceptions of the origin of the rocks of the earth imagined catastrophes of fire or water, processes alien to those of everyday experience. But the “ uniformitarian ” school, founded by James Hutton (1726-1797) and expounded by Sir Charles Lyell (1797-1875), produced evidence to show that much, at any rate, of the structure of the surface of the globe was produced by the action of causes and processes still going on under our eyes. The deposition of material by the action of seas and rivers and other natural agencies, *e.g.* volcanoes, &c., was seen to need only time enough to produce beds of rock like those which make up our mountains. Comparison of the fossil remains of plants and animals found in different kinds of rock then enabled geologists to classify the rocks, and place them in a chronological sequence. Moreover, it became evident that a series of animal and plant types was associated with the gradual formation of the rocks, and that the age both of the earth itself and of the organic life found on it was much greater than had been suspected. The few thousand years of received cosmogonies stretched out into untold millions, during which the same familiar laws described the phenomena of development. The remains and traces of man, found, it is true, only in the later sedimentary deposits of the earth, still were enough to prove his existence through ages beside which the dawn of history was but as yesterday. As Newton had extended known principles throughout the gigantic spaces of the heavens, so the later geologists pushed them back over enormous epochs of time. The extent of the kingdom of ordered knowledge expanded both in space and time to a degree truly marvellous.

The discovery by Sir George G. Stokes (1819-1903), R. W. Bunsen (1811-1898) and G. R. Kirchhoff (1824-1887), that the spectroscope gave a means of investigating the chemical composition of the sun and the stars, brought another set of phenomena under the control of ter­restrial experiment. Moreover, the differences in stellar spectra once more suggested the idea of cosmical development, familiar from the nebular hypothesis of Laplace.

Besides the direct extension of the dominion of science pro­duced by geology and spectroscopy the new results emphasized the idea of development, and prepared the way for the biological work of Charles Darwin (1809-1882).

The origin of living beings from a few ancestral types was an old conception, but Darwin first found an adequate intelligible cause in the slow action of sexual selection, joined to the pressure