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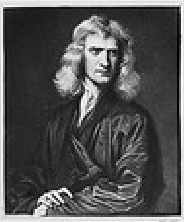
THE RISE OF MODERN SCIENCE

After Descartes theories of the origin of the world and life, many of them fantastic, came thick and fast. All scientific speculation was profoundly influenced, directly or indirectly, by the work of Sir Isaac Newton whose Theory of Gravitation was the first important natural law of universal applicability. At first individual thinkers, Buffon, Kant and others, tried to give a complete synthesis of human knowledge and describe the development of the world from its original state down to the present. Later, different aspects of the problem became the provinces of the specialised sciences Astronomy, Geology, and Biology

THE ORIGIN OF THE EARTH

ISAAC NEWTON (1642–1727)

was until the twentieth century the greatest single figure, and his chief work, the *Principia*, the most influential single book, in the history of Science. Although several English and foreign scientists had been independently groping towards a formula to explain the planetary motions it was reserved for Newton's mathematical genius to find this formula and to show in detail how it explained not only the elliptical orbits of the planets but also the apparently arbitrary movements of the comets, the tides of the sea and the fall of objects to the earth.



ISAAC NEWTON
Engraving after portrait by Kneller in the possession of the Earl of Portsmouth

TITLE PAGE OF NEWTON'S 'PRINCIPIA'
2nd issue of first edition 1687

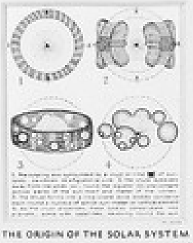
PHILOSOPHIAE NATURALIS PRINCIPIA MATHEMATICA (1687)

expounds Newton's principles of mechanics and demonstrates his Law of Universal Gravitation which he summed up in the General Scholium at the end of the book as follows: 'The power of gravity operates .... according to the quantity of solid matter .... decreasing always as the inverse square of the distances.' Newton later tentatively suggested that, supposing the original condition of the Universe to have been a conglomeration of discrete particles, Gravitation might well be the motive force which had formed this primordial matter into the ordered Universe.

EMANUEL SWEDENBORG
Frontispiece of Swedenborg's Principia 1734

EMANUEL SWEDENBORG (1688–1772)

made valuable contributions to science which were long obscured by uncritical enthusiasm for his mystical theology. His cosmogony forms a link between those of Descartes and of Kant, who may well have been influenced by him. He assumed an original space of Sun-matter round which collected a dense rind of sun-spots; owing to rotation these sun-spots broke down into the planets and their satellites which, however, contained a nucleus of original sun-matter.



THE ORIGIN OF THE SOLAR SYSTEM
After Swedenborg E. 'Principia Rerum Naturalium' Dresden and Leipzig 1734. Vol I Plate XXVI

THE ORIGIN OF THE EARTH
After Buffon G.L.de. 'Histoire Naturelle' Paris 1749 etc.

GEORGES LOUIS LECLERC DE BUFFON (1707–1788)

though primarily a biologist, essayed in his *Histoire Naturelle* to cover all scientific knowledge. He made no attempt to account for the origin of the sun itself, but derived the planets from the sun by the action of a comet. He supposed that the planets had been furrowed off the edge of the sun by a glancing blow from a comet and hurled out into space where they continued to revolve round the sun in the same plane.

GEORGES LOUIS DE BUFFON
Engraving by Hart after portrait by Drouais in the collection of the Institute of France

IMMANUEL KANT
Engraving after miniature by Barnes in the Stadtgeschichtliches Museum, Königsberg

IMMANUEL KANT (1724–1804)

like Newton, postulated an original state of the universe in which discrete primordial matter was uniformly distributed and was formed into the ordered universe in the following stages:

(1) Owing to the force of Gravity Primordial Matter congregated in isolated masses which were caused to revolve by the repulsive force also inherent in matter.

(2) The heavier particles tended towards the centre forming the sun and stars. (Kant, influenced by Thomas Wright of Durham, saw order in the Stellar Universe and in the concentration of stars round the Milky Way)

(3) The lighter particles of Matter round each Nucleus rotated in rings, all in the same plane, which in their turn condensed round a Nucleus and formed planets.

(4) This process was further repeated to form the satellites of some planets.

THE NEBULAR HYPOTHESIS of LAPLACE
After Fisher, Clyde, 'Exploring the Heavens' 1937.

The above diagram, though originally intended to illustrate only the hypothesis of Laplace, also applies to Kant's theory. In the centre is the sun and round it the various rings, each in process of condensing round a nucleus or planet. The outer rings have already broken and are well on their way to becoming consolidated bodies. The Nebular Hypothesis has only comparatively recently been abandoned (see Section 15). In its Kantian form it does not account scientifically for rotation, a problem which has, in fact, yet to be solved. Further, it is now known that gaseous matter on the scale of the solar system would not coalesce during rotation but disperse. It is, however, probable that Laplace's theory would account for the birth of stars from nebulae, about which much more is now known owing to the work of observers such as William and John Herschel.

PIERRE SIMON de LAPLACE (1749–1827)

independently reached a very similar position to that of Kant, but he made no attempt to account for the origin of the Universe as a whole. His Famous Nebular Hypothesis consisted of the following stages:

(1) An original incandescent gaseous nebula, rotating from West to East.

(2) As it cooled the rate of rotation increased and a ring of Matter was formed.

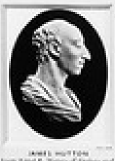
(3) This process continued until the original nebula had shrunk to our present sun.

(4) Meanwhile the rotating rings of gas began to coalesce into stable bodies, the planets.

(5) The planets themselves can form satellites by the same process.

PIERRE SIMON DE LAPLACE
Engraving by J. Posselwhite

The FORMATION of the EARTH



JAMES HUTTON
From Zittel K. 'History of Geology and Palaeontology' London 1901, facing p. 33

JOHN PLAYFAIR
Engraving by J. Thompson

After Descartes it was generally realised by scientists that the development of the earth from its original state needed a long period of time. The first to express this clearly was (see above) who postulated seven *Epoques de la Nature*, covering (1) the cooling and (2) the consolidation of the earth, (3) the condensation of water upon it, (4) the upheaval of the mountain systems, (5) the torrid age of great animals and the appearance of man, and (7) the present period of man's domination; lasting approximately 85,000 years until the present.

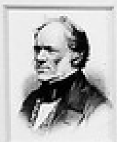
During the eighteenth century much work was done in all countries and dispute centred mainly on two points:

(1) Had the earth changed by a series of upheavals (as, for example, Buffon supposed) or by a gradual process?

(2) Were these changes due to the action of water or of fire?

JAMES HUTTON (1726–1797) backed up by his friend JOHN PLAYFAIR (1748–1819) caused a decisive turn in both these questions. They showed that geological processes should be understood as due to the same natural causes as can now be observed in operation, although they thought it impossible to compute the actual age of the world. Further, while emphasising the part of water as a superficial agent in the formation of the world, they declared the formation of certain rocks and the consolidation of strata to be due to fire & heat. CHARLES LYELL widely popularised this standpoint in his influential work *The Principles of Geology* London 1832, and though it is now modified in many respects the fundamental truth that the present is the key to the past remains the watchword of the geologist.

Meanwhile scientists were patiently building up the present geological hypothesis (see Section 16) of systems, epochs and eras, (the nomenclature of which bears witness to the varied nationality of the investigators) & tentatively assigning actual periods of time for geological processes.



CHARLES LYELL
Engraving by Stodart after a photograph

GEOLOGICAL FORMATIONS IN THE VALLEY OF THE JED, SCOTLAND
After Hutton J. 'Theory of the Earth' Edinburgh 1795. Vol I Plate III

Formations where horizontal strata succeed vertical led Hutton to declare that the lower strata had been consolidated and heaved up by heat before sinking again so that the sea laid down upon horizontal strata which in their turn were consolidated and raised.

The EVOLUTION OF LIFE

During the period from Descartes to Darwin there were three main problems in Biology:

(1) How long had there been life on the earth?

(2) Were species immutable or variable?

(3) Was man a special creation or had he evolved from a lower form of life?

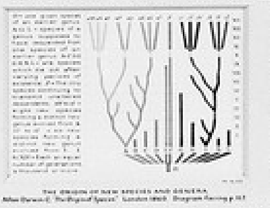
GOTTFRIED WILHELM LEIBNITZ (1646–1716) in his *Protogaea* (1749) stressed the importance of fossils as examples of living forms, and not 'sports of Nature' as was often believed. Though he was by no means the first to take this view (which had been held by Leonardo da Vinci among others) Leibnitz's standing as a philosopher lent validity to his arguments and his belief that fossils sometimes represent now extinct animal forms foreshadowed the end of the belief in the fixity of species.

BUFFON (see above) in opposition to his great contemporary, the systematist Linnaeus, asserted that the boundaries between species were fluent and not to be rigidly defined.

JEAN BAPTISTE de MONET LAMARCK (1744–1829) emphasised the continuity of living things and the artificiality of classification. He believed that living creatures change according to their environment and transmit these changes to their descendants.

CHARLES DARWIN (1809–1882) was thus not the originator of the Theory of Evolution, any more than Newton was of the Theory of Gravitation, but he crystallised, illustrated, proved and popularised a general tendency in biological thought. His main thesis (*Origin of Species* 1859) was that the present species have developed and been differentiated from lower forms by means of Natural Selection, that is, the fact that certain chance modifications from the norm were more fitted to survive. This theory was applied to the Evolution of Man from the apes (*The Descent of Man* 1871) and from then onwards the early history of Man's ancestors has been the province of the Physical Anthropologist and the Prehistorian. (See Gallery II)

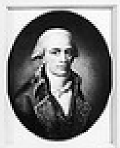
It is to be noticed that so far Science has only succeeded in pushing back the history of life and human life in particular further and further into antiquity, the ultimate origin of it is a still unsolved problem.



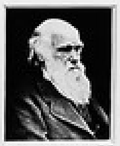
THE ORIGIN OF NEW SPECIES AND GENERA
After Darwin C. 'The Origin of Species' London 1859. Diagram facing p. 117

Diagram illustrating how two or more genera are produced by descent with modification (here shown by divergence in colour) from two or more species of the same genus. The difference between the varieties at end of any very ascending species between the Roman numerals represents a thousand or more generations.

GOTTFRIED WILHELM LEIBNITZ
Engraving from 'Acta Eruditorum' Part IV, Leipzig 1717



JEAN BAPTISTE de MONET LAMARCK
Engraving by Maguire after painting by David



CHARLES DARWIN
From a photograph