of Faraday. A very excellent account of Faraday, with also a popular explanation of the nature of his physical and chemical discoveries will be found in Dr. William Garnett's *"Heroes of Science—Physicists"* (New York: E. & J. B. Young & Co.). The student will also find that Faraday occupies an important place in Miss Buckley's *"Short History of Natural Science"* (New York: D. Appleton & Co.).

2. The standard *"Life of Faraday"* is the *"Life and Letters,"* by his friend, Dr. Bence Jones, the secretary of that "Royal Institution" in which Faraday labored so long. This work however is larger than the ordinary reader will usually have time for. (London: Longmans. 2 vols., 8vo.)

3. Perhaps the one best book for the ordinary reader to get in order to obtain a good idea of Faraday's life and work is *"Michael Faraday,"* by J. H. Gladstone, Ph. D., F. R. S. (son of William Ewart Gladstone). It is only of 172 pages, and is exceedingly interesting from beginning to end. (London: The Macmillan Co.)

4. Professor Tyndall's *"Faraday as a Discoverer"* was "a labor of love." Tyndall was Faraday's assistant, and afterwards his successor. He considered Faraday the greatest man in physical science in the century. The work is peculiarly valuable from its clear and easily understood exposition of the nature of Faraday's discoveries. (New York: D. Appleton & Co., $1.00.)

Sir Charles Lyell

XII. SIR CHARLES LYELL

1797-1875

BIOGRAPHICAL STUDY

BY JOHN EBENEZER BRYANT, M. A.

In the history of almost every science there has almost always been some one man to whom that science owes more than to any other—who found it based on wrong principles, and directed in its development to wrong ends, and who by his genius, his devotion, his industry, was instrumental in removing it from its false foundations and basing it on principles that are in harmony with nature. Such a man, in the history of the science of geology, was Charles Lyell. While not the historical founder of geology, nor, indeed, the first eminent worker in the science, nor by any means the only eminent worker in it during the epoch of his devotion to it, yet nevertheless he is justly to be considered the founder of the modern science of geology. When he began his career he found geology crude in its aims and scope, and in its methods more or less unscientific. When he finished his labors he left the science definite in both its scope and its aims, and as strictly

governed by the laws of inductive reasoning as any science in the whole realm of modern knowledge.

Lyell was a favored child of fortune. In addition to the ability and genius with which he was endowed, he was endowed with gifts and graces of disposition and character scarcely less remarkable. He had industry and zeal. He had judgment and tact. He had natural courtesy of manner and a kind heart. He had true nobility and dignity of soul. In the course of a long life he never made an enemy—he even had scarcely a detractor—and the friends he made comprised nearly every man of eminence in England, especially in the walks of science. He was peculiarly fortunate in his domestic relationships. His father, who was a man of scholarship and culture, and in his way a distinguished naturalist, was also a man of wealth. He was thus not only able to sympathize with his son's scientific aims, but he could do much more. In his lifetime he gave him such an allowance as made it possible for him to live in social dignity and comfort, and devote his whole time to his scientific pursuits. At his death he left him such an estate as made his pecuniary position more care-free and socially dignified even than before. Lyell, too, received a good education, and had in his scientific career the inestimable advantage of being well trained (as well as naturally gifted) in the art of expression. His marriage, too, was a happy one. His wife, who was also an exceptionally beautiful woman, was a woman of culture and of scientific tastes, like himself. In addition she was a woman of social tact and personal charm, both in conversation and in manner, and thus able to make his home what it in reality became—a social center for men and women interested in scientific pursuits throughout all the

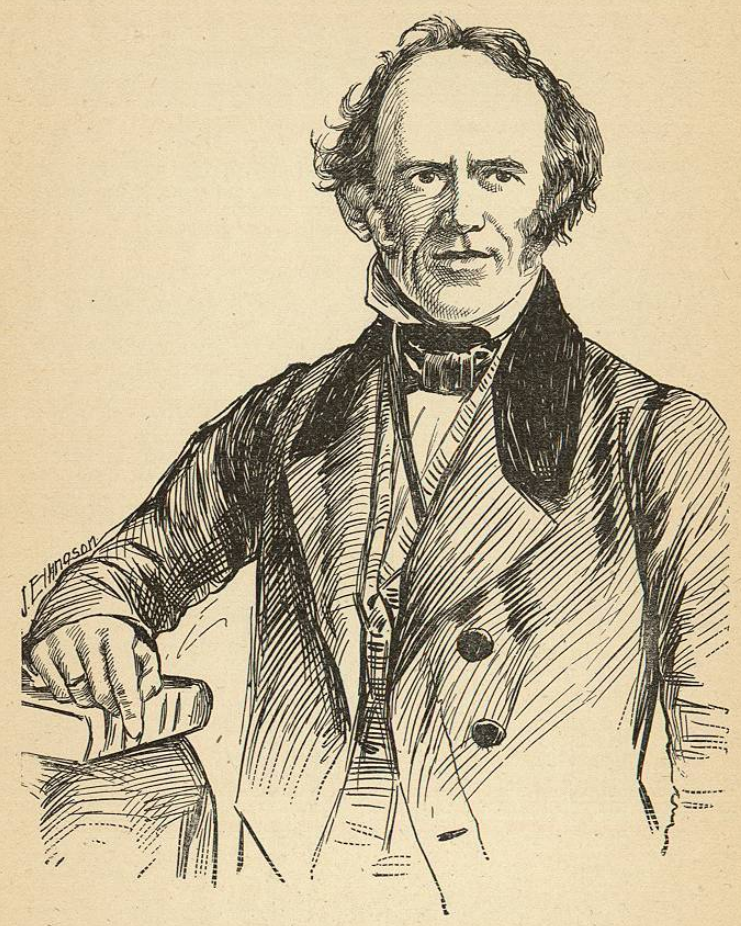
kingdom. In only two things did fortune seem to restrain her hand in dealing with Charles Lyell. He had no children. But this privation was to some extent compensated for by the fact that it left him free to devote himself wholly to his science; and also by the fact that in the son of his brother, who was also the son of his wife's sister, he found talents, tastes, and a disposition, such as he could have but wished for in a son of his own. He also suffered more or less all through life from a weakness of the eyes. But in every other respect he was, through the working years of his life, both well and strong.

The details of Lyell's life are so few and unstriking that they can scarcely be made into a narrative. He was born at Kinnordy, Forfarshire, Scotland, November 14, 1797. The family estate was at Kinnordy; but soon after Lyell's birth his father moved to the south of England, where, in the New Forest, he resided for twenty-eight years. Lyell was sent to good schools, and though his record as a student was not remarkable, it was creditable. He used to gain prizes for speaking (reciting), and for Latin and original English composition. Once he won a prize for English verse. His principal delight as a boy was collecting, and he became an ardent though unscientific entomologist. It was not until he was at Oxford, whither he went soon after he had completed his eighteenth year, that his real interest in science began. In his twentieth year he attended the lectures of the enthusiastic geologist, Professor Buckland, and from that date forward Charles Lyell's whole soul was devoted to geology. In his twenty-first year he had the good fortune of accompanying his parents and his sisters on an extended tour through France, Switzerland, and Italy, and it was

on this tour that he began that wonderful series of out-of-door observations for which his career is so distinguished. Shortly after his return from this tour he received his degree, and in deference to his father's wishes he began the study of law. The weakness of his eyes, however, prevented him from pursuing the study of his chosen profession steadily, and it was not until his twenty-eighth year that he was called to the bar. And even when at last he began the practice of his profession he devoted himself to its duties only perfunctorily. His principal affection was for geology. And though, still in deference to his father's wishes, who thought it would be best for him to have at least some nominal profession, he went on circuit for two years, the connection with law was never much more than nominal and soon was dropped altogether. But he had become a fellow of the Geological Society in his twenty-second year, and a fellow of the Royal Society in his twenty-ninth year, and was a regular contributor of scientific memoirs to the various scientific journals concerned with his specialty. In his thirty-third year (1830) the first volume of his epoch-making book, "*The Principles of Geology,*" was published. In the next year he was made professor of geology at King's College, London. And in the year thereafter (1832, at the age of thirty-five) he married, his bride being Miss Mary Horner, daughter of Mr. Leonard Horner, who was also an enthusiastic and distinguished geologist.

The geologic principle which Lyell was most concerned in establishing was briefly this: In the explanation of geologic records the causes of past geologic action are to be sought for by observing what means nature uses to effect her present geologic action. His theory summarized

may be stated in a single sentence—"All changes in the crust of our earth have been brought about by causes that are still in action." In other words, in the changes which nature produces to-day by ordinary causes—as, for example, the wearing away of rock or soil by the action of rain, snow, ice, etc., the washing of silt down river beds and its deposition over the surface of the sea at river mouths by the action of moving water, the growth of rock structure on mountain sides by the action of volcanoes, the growth of rock structure in the sea by the action of coral polyps—in changes such as these and others in infinite number that might be instanced—changes that are produced daily everywhere by causes that are easily observable and easily explainable—may be seen the counterpart of all the changes which can be discovered to have taken place in the whole earth's crust, with all its infinite stratifications, eruptive deposits, and modifications of structure of every sort. This theory was in direct opposition to the theory which at the beginning of Lyell's career was held by almost every eminent geologist living—for example, by Lyell's own preceptor, Buckland. The accepted theory was that in the main the changes observable in the earth's crust were the results of an adjusting power altogether different from what is commonly understood as the laws of nature. The Noachian deluge was the instrument most commonly accepted as having been concerned in effecting these changes. And when it was seen that this deluge could not possibly have been instrumental in effecting more than the smallest fraction of the changes that had taken place in the earth's crust, other deluges were brought in as assisting instruments. And, in addition to deluges, volcanic upheavals and continental



SIR CHARLES LYELL.

earthquakes were postulated. In short, instead of supposing that the operations of nature are uniform—yesterday, to-day and forever the same—it was supposed that nature worked by cataclysms. And thus, as soon as Lyell's theory was well understood, the scientific world was divided into two camps—the "cataclysmists" (or "catastrophists," as they were sometimes called) on the one side, and the "uniformitarians' on the other. Long, however, before Lyell had finished his geological labors the cataclysmic theory of geologic change was abandoned, and the scientific world became what it now is in its belief—that is to say, wholly uniformitarian.

Such, in bald language, is a brief statement of the great doctrine with which Lyell's name in the history of geologic science is principally associated. But this doctrine was not wholly original with Lyell. It had been announced as early as 1788 by the celebrated Scotchman, Dr. Hutton. Hutton's theory, however, had never been accepted by the scientific world; and by the time that Lyell began to devote himself to geology it had almost been forgotten. Lyell gave to Hutton the credit of first propounding the theory, and looked upon himself only as its expositor. It was Lyell, however, that established the theory. But it was not merely his statement of the theory in fascinating language, and the skillful deductive reasoning he used, that won for it its credit. It was his support of the statement by a wealth of observed geologic fact, obtained in every part of the globe, such as in the whole history of the science had never been got together before, that brought the world to see that the way to explain the conformation of the earth's crust is not by assuming that nature acts in spasms and paroxysms whose character, duration and extent are

all unlike anything observable in her action to-day, but by watching closely how she performs her work at the present time, and then tracing carefully the relationship of her present action to her action in all past time. It must not be supposed that Lyell had his theory perfect in all its full development when in 1830, at the age of thirty-three, he first published his "*Principles of Geology.*" It is true that he had the germ of his theory fairly in his mind at that time. But he brought out no less than eleven editions of his famous book, and in every edition he made modifications in the statement of his theory, called for by newly discovered facts and newly ascertained principles. For example, in the beginning of his uniformitarian career he believed with Hutton that the geologic history of the world was made up of mere changes. He saw no beginning. He anticipated no end. What nature did with one hand she undid with the other; and this was always so. The world might have existed indefinitely in the past, just as it might exist indefinitely in the future—with slow upheaval followed by slow submersion, and all the minor changes that these greater changes might effect following one another in due succession. A "cosmogony," or theory of the development of the universe from a state of homogeneous simplicity to a state of heterogeneous complexity, and back again, perhaps, to a state of homogeneous simplicity, he never dreamed of. Also, the influence, in effecting changes in the earth's crust, of causes other than purely geologic ones he was disposed to ignore—as, for example, the influence of a possible change in the inclination of the earth's axis to the plane of the ecliptic. But long before he came to the end of his career Lyell saw good reason to modify his attitude toward such matters. And just as

in his youth he had been able to advance the kingdom of knowledge by keeping a mind open to the inspiration of truth, so in his later days he conceived that it was still his duty to evince a like willingness to be led when truth should appear to guide. Lyell, more perhaps than any other great scientist of modern times, was a learner until the day of his death. And no greater or more instructive example of true modesty of soul and open-hearted loyalty to truth is to be found in the whole history of science than is presented by his conduct when in the seventh decade of his life he openly retracted views that he had held for a lifetime, and formally avowed others that he had for a lifetime opposed, as soon as he saw that these newer views had the support of impregnable fact.

Lyell's personal history from the time of his marriage forward till his death was but the continuation of his history before his marriage, except that perhaps he devoted himself more exclusively than ever to his chosen life's work, and freed himself more wholly than ever from all cares and duties that might encumber him in his pursuit of it. He resigned his position as professor in King's College, and it was with difficulty that he could be got to accept even positions of honor connected with the various learned societies he belonged to. He was, however, for many years a member of the council of the Royal Society, and for several years he was elected chairman of the Geologic Section of the British Association. But the main effort of his life was spent in field explorations, in reducing his observations to writing and presenting them as memoirs to scientific associations, and in preparing for the press the successive editions of his "*Principles of Geology*" and its more technical companion, "*The Ele-*

ments of Geology." His life, however, was one of great activity. His travels were almost continuous. He seems, in his geologic enthusiasm, to have visited every part of Europe except Russia, Turkey and Greece, again and again. In his sixty-first year he descended the crater of Vesuvius and spent fourteen days examining the craters of Aetna. He made several long visits to the United States and Canada, during which he examined the coal-fields of Pennsylvania, Ohio, Virginia, Alabama, and Nova Scotia, and studied such great geologic object lessons as the Dismal Swamp of Virginia, the earthquake region of New Madrid on the Mississippi, and the gorge at Niagara, besides doing innumerable other pieces of geologic work. Travel was, indeed, in his view the first, the last, and the constant duty of the geologist. Even when in 1873 his wife died, she who for forty years had been his working companion in almost every journey he had ever made, he still continued his habit, and visited from time to time old geologic haunts in Germany and Scotland. In 1863 he had published his second epoch-making book, *"The Antiquity of Man,"* and he prepared successive new editions of it up to 1873. But an end comes to all things, even to energy and activity such as Lyell's. In 1848 he had been made a knight. In 1864 he had been made a baronet. Oxford long ago had granted him her D. C. L. In 1874 Cambridge granted him her LL. D. And innumerable other honors he received. Finally, February 22, 1875, full of years as well as honors, he passed away. But by the unanimous desire of men of science everywhere one further honor was bestowed upon him. He was buried in the nation's mausoleum, Westminster Abbey. And as

an appropriate description of his work and aims, these words were engraved upon his tomb:—

"Throughout a long and laborious life he sought the means of deciphering the framentary records of the earth's history in the patient investigation of the present order of nature."