Charles Lyell

He founded modern historical geology and set the stage for the achievement of Charles Darwin. Until late in his career, however, he was reluctant to accept the idea of evolution

by Loren C. Eiseley

"I feel as if my books," Charles Darwin once confessed, "came half out of Sir Charles Lyell's brain." The great biologist was admitting to no more than the simple truth. Sir Charles Lyell, who remained until late in his career a reluctant evolutionist, was paradoxically the ground-breaker for the triumph of the *Origin of Species*.

Lyell is remembered chiefly as a founder of modern historical geology. But he was also a biologist whose studies form the backbone of the achievement of Darwin and Alfred Russel Wallace. In his day he addressed tabernacles in both England and America full of people eager to hear the world-shaking views of the new geology. Today the man in the street has forgotten him. By a curious twist of history, Darwin replaced Lyell as a popular idol. Yet this gaunt-faced man who ended his days in near-blindness was one of the greatest scientists in a century of distinguished men.

A generation before Darwin he took a world of cataclysms, supernatural violence and mystery, and made of it something plain, expected and natural. If today we look upon our planet as familiar even when its bowels shake and its volcanoes grumble, it is because Lyell taught us long ago the simple powers in the earth.

It was as though we had been unable to see the earth until we observed it through the eyes of Lyell. Ralph Waldo Emerson wrote at mid-century: "Geology, a science of forty or fifty summers, has had the effect to throw an air of novelty and mushroom speed over entire history. The oldest empires—what we called venerable antiquity—now that we have true measures of duration, show like creations of yesterday. . . . The old six thousand years of chronology becomes a kitchen clock."

To Darwin and Wallace, Lyell gave the gift of time. Without that gift there would have been no *Origin of Species*. Geologic time is now so commonplace that the public forgets it once had to be fought for with something of the vigor that was later to be transferred to the evolutionary debates of the 1860's.

Lyell was, in modern terms, both zoologist and geologist. Indeed, he defined geology as that science "which investigates the successive changes that have taken place in the organic and inorganic kingdoms of nature." Today the splitting-up of science into numerous special disciplines has left Lyell one of the founders of historical geology. The world has tended to forget that he also wrote extensively upon zoological subjects, and that he exerted, as an older friend and influential scholar, a profound effect upon the career of Charles Darwin. "Lyell," remarked the great U. S. evolutionist Asa Gray in the year of Darwin's death "is as much the father of the new mode of thought which now prevails as is Darwin."

Yet in the first years of evolutionary controversy, beginning with Jean Baptiste de Lamarck and extending into the time of Robert Chambers and Charles Darwin, Lyell found himself popularly arrayed with the resistance to evolution. He was not to alter his public position until the autumn of his life. To us it may seem an almost willful rejection of the new age of science. Oddly enough we are wrong. Reading history backward is almost worse than not reading history at all. One must live both in a given time and beyond it to appreciate at once its complexities and its half-veiled insights.

Lyell's rejection of evolution was one of the first rational products of the new geology. A hint as to the nature of the situation is to be found in a passage in Lyell's *The Antiquity of Man*, published in 1863. The issue, to our modern eyes, is obscured by the terms in which it was argued. Lyell wrote: "It may be thought almost paradoxical that writers who are most in favor of transmutation (Mr. C. Darwin and Dr. J. Hooker, for example) are nevertheless among those who are most cautious, and one would say timid, in their mode of espousing the doctrine of progression; while on the other hand, the most zealous advocates of progress are, oftener than not, very vehement opponents of transmutation. We might have expected a contrary leaning on the part of both."

It is in the words "transmutation" and "progression," now unfamiliar, that the key to this mystery lies. When we come to know their significance, we will have learned that the road to the acceptance of evolution had unexpected turnings which, as we look backward, seem to have vanished, but which were real enough to the men of the 19th century. Before we can understand Lyell's position, this queer order of events has to be explored and comprehended.

Charles Lyell was born, the first of 10 children, to well-to-do parents in Scotland in 1797. His father possessed a strong interest in natural history and may have helped unconsciously to guide his son's interests in that direction. As Charles Darwin and Alfred Russel Wallace were later to do, the young Lyell collected insects in his boyhood. Absent-minded but versatile, tree-climber and chess player, he matriculated at Exeter College, Oxford, in 1816. Having early stumbled upon a copy of Robert Bakewell's *Introduction to Geology* in his father's library, he sought out Dean Buckland's geological lectures at Oxford, and from then on was a haunter of

chalk pits, rock quarries, caves and river terraces.

In 1818 he made the usual continental tour with his parents and sisters. The slow carriage travel of that day promoted leisurely observation, and Charles made the most of it. He saw the red snow and glaciers of the high Alps as well as the treasures that lie open to the observant in the flints of the common road. Lyell had not as yet settled upon a career in geology. He was destined for the law, and shortly after his graduation from Oxford he came to London to prepare himself for the bar.

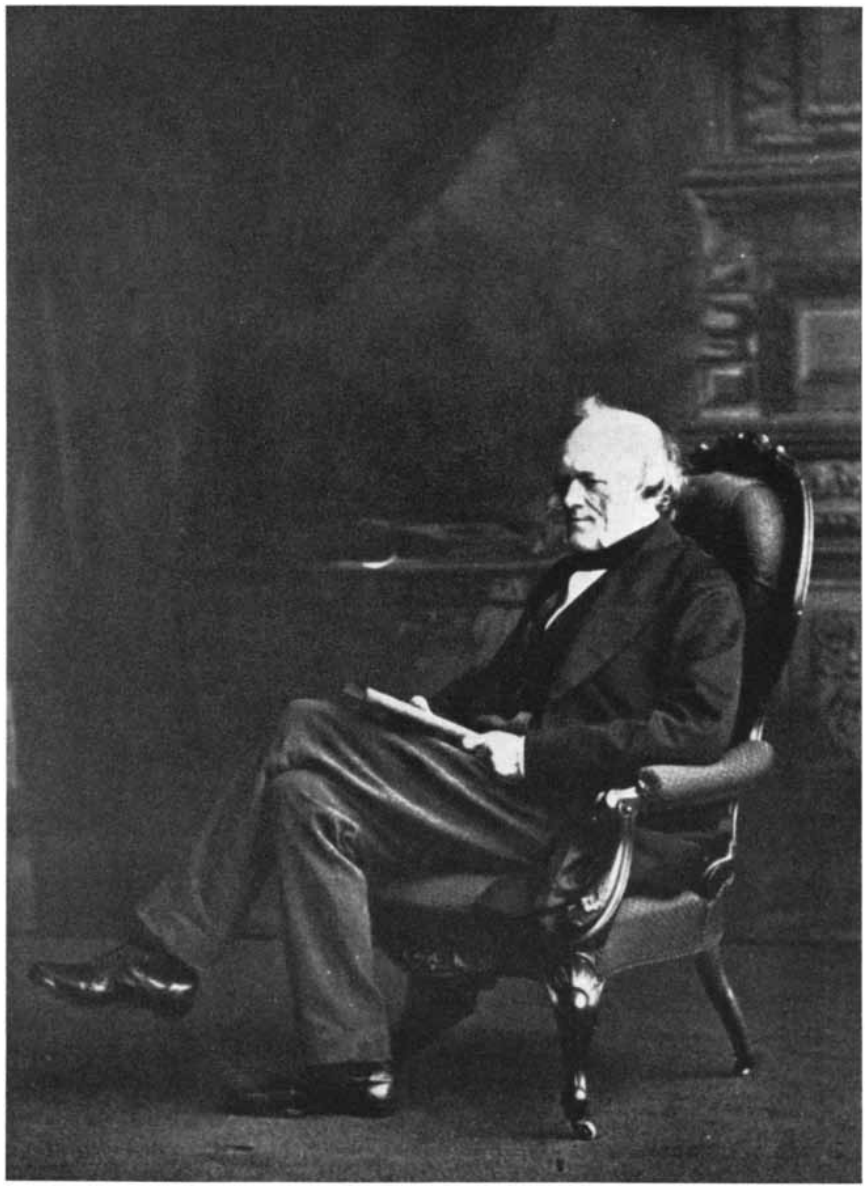
Even in London, however, Lyell was soon elected a Fellow of the Geological Society and joined the Linnean Society. Two handicaps tended to retard his legal career. His eyes were weak and troublesome, and he suffered from a slight speech difficulty, with which he was to contend bravely in his years as a lecturer on the natural sciences. When he was called to the bar in 1825 he was already contributing articles on scientific subjects to the *Quarterly Review*.

It has sometimes been intimated that Charles Lyell was "only an armchair geologist," that he was scientifically timid, a rich man's son who happened to dabble his way to success in a new science. But in those days there was little in the way of public support for science. Even the great schools were still largely concentrated upon the classical education of gentlemen. Only the man of independent means, like Lyell or Darwin, could afford to indulge his interest in science. With occasional struggling exceptions such as Wallace, it was the amateur who laid the foundations of the science of today. The whole philosophy of modern biology was established by such a "dabbler" as Charles Darwin, who never at any time held a professional position in the field. Charles Lyell and his great precursor, the Scotsman James Hutton, similarly laid the foundations of modern geology without claiming much in the way of formal institutional connections. Important though institutional and government support has come to be, it has led to a certain latent snobbery in professional circles. The amateur has had his day. But his was the sunrise of science, and it was a sunrise it ill becomes us to forget.

The charge that Lyell was an armchair worker will not stand against the facts. But even if the accusation held, the whole question would turn on what came out of the armchair. In actuality Lyell in his younger years made numerous trips to the continent to examine the evidence of geology at firsthand. Later, in the 1840's, he visited America, where he made similar ventures into the field, even though he was by then lecturing to thousands. As his biographer T. G. Bonney remarks: "Whenever there was hope of securing any geological information or of seeing some remarkable aspect of nature, Lyell was almost insensible either to heat or to fatigue." It is hard to see how a man suffering from bad eyes could have done more.

In support of the charge of scientific timidity, it is observed that Lyell opposed himself for many years to evolutionary views; it is said that his public and his private statements upon this score were vacillating. "How could Sir Charles Lyell," wrote one of Darwin's contemporaries, "for thirty years read, write and think on the subject of species and their succession, and yet constantly look down the wrong road?" From the vantage point of a hundred years this question can be answered. A whole new theory of life and time is not built by one man, however able. It is the product of multitudinous minds, and as a consequence it is also compounded of the compromises and hesitations of those same minds. Later, when the new world view comes to be ascribed, as it generally is, to a single individual such as Darwin the precursors of the discoverer begin to seem incredibly slow-witted.

Whatever men may think on this score, however, the record shows that



LYELL was born in Scotland in 1797 and died in 1875. He prepared for a legal career, but turned to geology. This photograph is in *Portraits of Men of Eminence*, published in 1863.

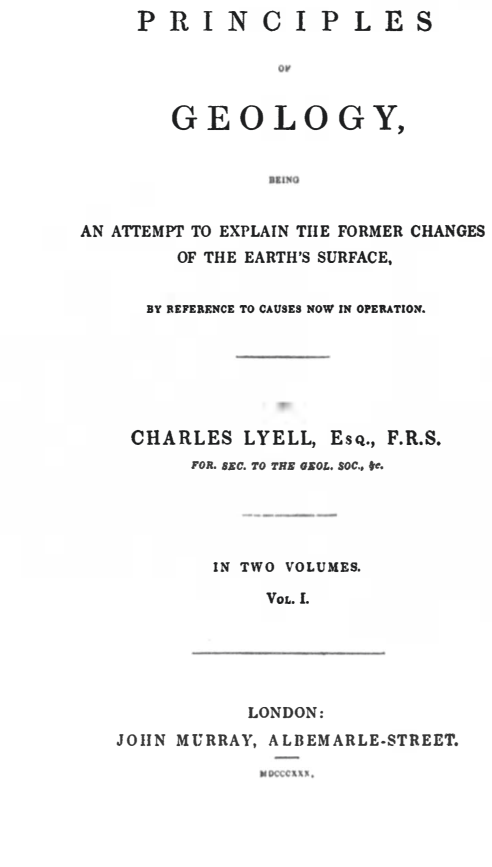
Lyell was a man of intellectual courage. He entered the geological domain when it was a weird, half-lit landscape of gigantic convulsions, floods and supernatural creations and extinctions of life. Distinguished men had lent the power of their names to these theological fantasies. Of the young Lyell, the "timid" Lyell who later strained Darwin's patience, a contemporary geologist wrote: "He stood up as a reformer, a radical reformer, denouncing all the old notions about paroxysms and solving every geological question by reference to the action of constant and existing physical causes. Never had a revolutionist harder work to get a sober hearing, or less prospect of overturning the works and conclusions of other men."

Geology at the beginning of the 19th century was known to many in England as a dangerous science. As such it both attracted and repelled the public. A body of fact and interpretation had arisen that could only be kept in accord with the Scriptural interpretation of earth's history by the exercise of considerable ingenuity. Theological authority was strong, and there was the greatest pressure upon geologists to avoid direct conflict with the church. Moreover, some of the early geologists were primarily theologians themselves, and were understandably anxious to reconcile geology with their religious beliefs. By degrees there had thus arisen a widely accepted view of geological history known as catastrophism.

This orthodox geological creed was an uneasy amalgam of the new scientific facts seen in the flickering, unreal light of mythological and romantic fantasy. Unlike the slow evolutionary successions that we recognize today, the record of geology was held to contain sudden catastrophic breaks. Mountain ranges were thought to be heaved up overnight; gigantic tidal waves, floods, paroxysms of the earth's crust were thought to mark the end of periods of calm. At such hours life vanished only to be restored through renewed divine creation, taking in the new period a more advanced form, and pointing steadily on toward the eventual emergence of man. It may thus be observed that the students of catastrophism had become aware of organic change in the rocks, but they saw the planet as having been molded by forces seemingly more powerful than those at work in the present day, and thus by implication supernatural.

Awareness of a succession of life-forms in the strata of the earth had been slowly increasing since the close of the 18th century. Furthermore, it was seen that these extinct forms of life showed an increasing complexity as one approached the present. Since the record of the land vertebrates is particularly incomplete and broken, there arose the idea that, instead of a genuine continuity of life from age to age, the breaks in the geological record were real breaks. There had been a genuine interruption between the life of one age and that of another; each geological period had its own flora and fauna largely distinct from that which preceded and followed it. The slow, grand progression of life was seen as through a jerky, discontinuous, ill-run motion picture.

Men still did not understand the real age of the earth, nor the fact that the



PRINCIPLES

OF

GEOLOGY,

BEING

AN ATTEMPT TO EXPLAIN THE FORMER CHANGES OF THE EARTH'S SURFACE,

BY REFERENCE TO CAUSES NOW IN OPERATION.

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FOR. SEC. TO THE GEOL. SOC., &c.

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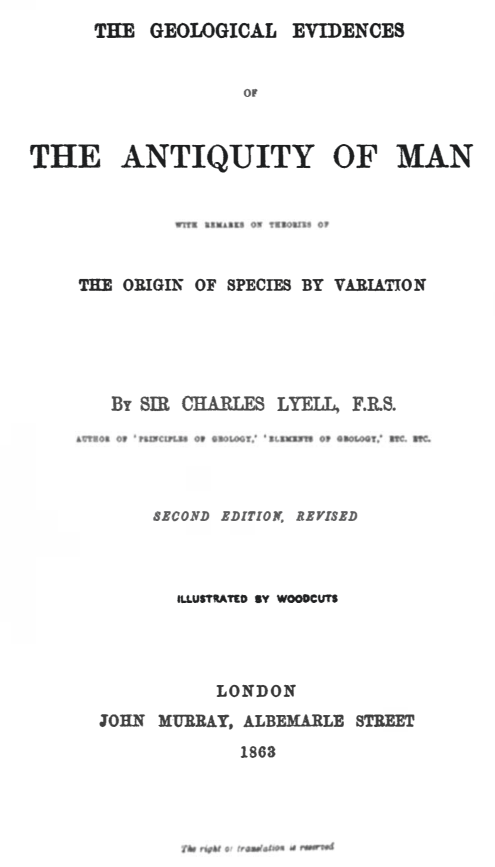

THE GEOLOGICAL EVIDENCES

OF

THE ANTIQUITY OF MAN

WITH REMARKS ON THEORIES OF

THE ORIGIN OF SPECIES BY VARIATION

BY SIR CHARLES LYELL, F.R.S.

AUTHOR OF 'PRINCIPLES OF GEOLOGY,' 'ELEMENTS OF GEOLOGY,' ETC. ETC.

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1863

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LYELL'S PRINCIPAL WORK was *Principles of Geology*, published in 1830. Although the title page reproduced at left states that the book has two volumes, Lyell later wrote a third. At right is the title page of *The Antiquity of Man*, which was published in 1863.

breaks they found in the records of the rocks were not world-wide, but rather only local discontinuities. The imperfections of the geological record, or the passages between the discontinuities, could only be learned through the piling-up of empirical evidence, a task that had only begun.

The catastrophic school had a powerful religious appeal. It retained both the creative excess and fury of an Old Testament Jehovah. "At succeeding periods," wrote Adam Sedgwick, one of Darwin's geological teachers at Cambridge, "new tribes of beings were called into existence, not merely as the progeny of those that had appeared before them, but as new and living proofs of creative interference; and though formed on the same plan, and bearing the same marks of wise contrivance, oftentimes unlike those creatures which preceded them, as if they had been matured in a different portion of the universe and cast upon the earth by the collision of another planet."

People thought in terms of a geotheological drama, a prologue to the emergence of man on the planet, after which no further organic developments were contemplated. The theory predicted a finished world which, in some eyes at least, could be compressed into the figurative week of the Book of Genesis. "Never," commented Lyell, "was there a dogma more calculated to foster indolence, and to blunt the keen edge of curiosity, than this assumption of the discordance between the former and the existing causes of change."

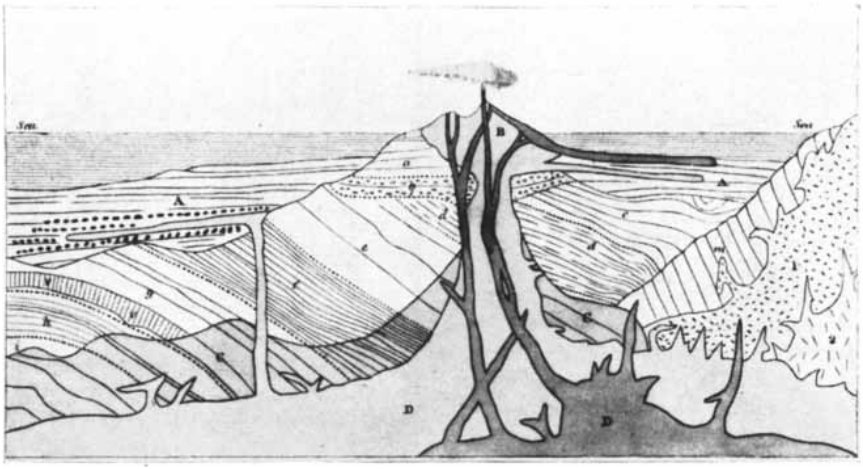
In this half-supernatural atmosphere Sir Charles Lyell in 1830 published the first volume of his *Principles of Geology*. Like most great ideas it was not totally original with its author. But to Sir Charles belongs the unquestioned credit of documenting a then unpalatable truth so effectively and formidably that it could no longer be ignored. In this respect again his career supplies a surprising parallel to that of Darwin. For Darwin too, at a later time, was the resurrector and documenter of forgotten and ill-used truths.

Lyell's principal precursor, James Hutton, died in intellectual eclipse in 1797, the very year that saw the birth of the man who was to revive his views—so tenuous and yet so persistent is the slow growth of scientific ideas. In the 1780's Hutton made the first organized and comprehensive attempt to demonstrate that the forces that had shaped the planet—its mountains, boulders and continents—are the same forces that can be observed in action around us today. Hutton had an ear for the work of raindrops, an eye for frost crystals splitting stones, a feel for the leaf fall of innumerable autumns. Wind and frost and running water, given time enough, can erode continents, ran his argument. Peering into the depths of the past, he could see "no vestige of a beginning, no prospect of an end."

Hutton, though not the first to suspect the earth's antiquity, nor the work that perfectly natural forces can perform, was the first to write learnedly and extensively upon the subject. His work fell, however, into undeserved neglect. He was criticized as irreligious. In England, particularly in the conservative reaction following the French Revolution, the catastrophism theory, with its grander scenery and stage effects, had a more popular appeal. The world of Hutton by contrast was an unfinished world still unrolling into an indeterminate future. Its time depths were immeasurable, and the public had recoiled from its first glimpses into that abyss.

Yet this was the domain, and this the philosophy, upon which Sir Charles Lyell was to force his colleagues to take a long second look. He was a more eloquent and able writer than Hutton. But beyond this he had the advantage of almost 50 years of additional data, including his own personal study of the continental deposits. "Lyell," remarks one of his contemporaries, "was deficient of power in oral discourse, and was opposed by men who were his equals in knowledge, his superiors in the free delivery of their opinions. But in resolute combats, yielding not an inch to his adversaries, he slowly advanced upon the ground they abandoned, and became a conqueror without ever being acknowledged as a leader."

By degrees the idea of gradual change (uniformitarianism, as it came to be called) succeeded the picture of world-wide catastrophes. Supposition and quasi-theological imaginings gave place to a recognition of the work of natural forces still active and available for study in the world about us. The disjoined periods of the catastrophists began to be seen as one continuous world extending into a past of awe-inspiring dimensions. The uniformitarian school began to dominate the geological horizon. With the success of the *Principles* Lyell became one of two or three leading figures in English natural science until the peak of Darwin's fame was achieved with the publication of the *Origin of Species* in 1859. It is no wonder that the young Darwin, just returned from the voyage



EARTH'S CRUST is depicted in Lyell's *Elements of Geology*. It is captioned: "Ideal section of . . . the Earth's crust explaining the theory of the . . . origin of the four great clafses of rocks." The classes were: aqueous (A), volcanic (B), metamorphic (C) and plutonic (D).

of the *Beagle* in 1836, gravitated so quickly to Lyell. It was Lyell's revision of geology that was to make Darwin's triumph possible.

Sir Charles Lyell had been raised in a more orthodox home than Charles Darwin. In fact, he was to confess in afteryears that it cost him a severe struggle to renounce his old beliefs. Nevertheless, in reviving the conception of limitless time, and in abandoning the notion of world-wide breaks in the geological record as urged by the catastrophists, Lyell was inevitably forced to confront the problem of life itself in all its varied appearances. His great predecessor, Hutton, had been largely able to avoid the issue because of the lack of paleontological information. In Lyell's time, however, the questions pressed for answer.

The catastrophist doctrine had given birth to a kind of romantic evolutionism to explain the increasing complexity of life. This was the doctrine of "progression" which Lyell opposed in many of his writings from the time of the *Principles* onward. Progressionism was the product of the new paleontology which had discovered differences among the life-forms of successive geological eras. The theory can be said to have borrowed from Lamarck the conception of a necessary advance in the complexity of life as we ascend through the geological strata to the present. Instead of establishing biological continuity (the actual physical relationship between one set of forms and their descendants) the progressionists sought to show only a continuity or an organic plan in the mind of God between one age and another. There was, in other words, no phylogenetic relationship on the material plane between the animals of one era and those of a succeeding one.

Progressionism thus implied a kind of miraculous spiritual evolution which ceases only when the human level has been attained. The idea is confusing to the modern thinker because he tends to read back into this literature true evolutionary connotations that frequently were not intended by these early writers. The doctrine is interesting as a sign of the compromises being sought between an advancing science and a still-powerful religious orthodoxy.

"I shall adopt a different course," the young Lyell had written when he was contending for the uniformitarian view in geology. "We are not authorized in the infancy of our science to recur to extraordinary agents." The same point of view led him, in company with T. H. Huxley, Joseph Hooker and, later, Darwin, to reject the claims of progressionism. All of these men, Lyell foremost among them, were uniformitarians in geology. They believed in the play of purely natural forces upon the earth. They refused or were reluctant to accept the notion of divine interposition of creative power at various stages of the geological record. They felt in their bones that there must be a natural explanation for organic as well as geological change, but the method was not easily to be had. Since Lyell was the immediate parent of the new geology, and since he was committed to natural processes, he was continually embarrassed by those who said: "You cannot show how nor why life has altered. Why then should we not believe that geological changes are equally the product of mysterious and unknown forces?"

We are now at the crux of the reason why Lyell was dubious about notions of "transmutation"—the term then reserved for ideas implying true physical connection among the successions of species or, as we would say, "evolution" from one form to another. Lyell's attitude toward evolution was influenced by the antipathy that he felt toward progression, toward the unexplainable. In bracketing the two together he in effect was indicating the need of a scientific explanation of organic change, if change indeed was demonstrable.

Beginning with the *Principles of Geology*, in which the second volume and part of the third are devoted to biological matters, Lyell had sought to examine the biological realm with an eye to answering the challenge of the catastrophist progressionists. As a consequence he came close to, but missed the significance of, the natural-selection hypothesis which was to establish the fame of Charles Darwin. It was here that he took the wrong turning that led him away from evolution. Yet ironically enough, though Lyell failed to comprehend the creative importance of natural selection, he did not miss its existence. In fact, through a strange series of circumstances just discovered in the literature, it is likely that he was fundamentally instrumental in presenting Darwin with the key to the new biology. He was so concerned, however, to array the evidence against the doctrine of progression that he missed the support that the same evidence gave for a rational explanation of the origin of species.

Against the progressionists' idea of mass extinction at each break in the geological record he cited the imperfections in that record. "There must," he contended, "be a perpetual dying out of animals and plants, not suddenly and by whole groups at once, but one after another." Although not solving the problem of the emergence of new forms of life, Lyell by arguing for geological continuity was bringing the question of extinction and of the origin of new species within the domain of scientific investigation.

He countered the progressionist hypothesis with a short-lived "nonprogressionism" in which he argued that the discovery of higher forms of life in older strata would demonstrate that the progressionist doctrine was based solely upon the fallible geological record. This retreat from straight evolution on the part of Lyell was somewhat wavering, but it continued into the 1850's. There is no doubt that it was an attempt philosophically to evade a problem which

threatened to interpose into his system something miraculous and unexplainable that savored of the catastrophist doctrines he had struggled for so long to defeat. Only with the triumph of Darwin would a uniformitarian, a "naturalistic," explanation for the mutability of life be available to the uniformitarian followers of Lyell. It was only then that Huxley, Hooker and finally Lyell himself became converts to evolution, at a time when it was still being resisted by such men as Sir Richard Owen and Louis Agassiz—old-style catastrophists and progressionists who at first glance one might think would have eagerly embraced the new doctrine of genuine physical evolution.

Although the question has been obscured by hazy difficulties of terminology, Sir Charles Lyell had already described before Darwin the struggle for existence and, up to a certain point, natural selection. He had not, however, visualized its creative aspect. Lyell made the first systematic attempt to treat the factors affecting the extinction of species and the effects of climatic change upon animal life throughout the long course of ages. "Every species," Lyell contended, "which has spread itself from a small point over a wide area must have marked its progress by the diminution or the entire extirpation of some other, and must maintain its ground by a successful struggle against the encroachments of other plants and animals." He goes on to speak of "the tendency of population to increase in a limited district beyond the means of subsistence." Nor was Lyell unaware of plant and animal variation, although he believed such variation to be limited. "The best-authenticated examples of the extent to which species can be made to vary may be looked for in the history of domesticated animals and cultivated plants," he wrote, long before Darwin's investigations.

But Lyell did more than this. In the *Principles of Geology* he marshaled a powerful attack on the possibility that new evolutionary forms might be able thus to maintain or perfect themselves. Lyell advanced what he called his principle of "preoccupancy." In essence this principle simply assumes that creatures or plants already well fitted for occupying a given ecological zone will keep any other forms from establishing themselves in the new habitat, even assuming that the competitors are capable of evolving. "It is idle," said Lyell, "to dispute about the abstract possibility of the conversion of one species into another, when there are known causes so much more active in their nature which must always intervene and prevent the actual accomplishment of such conversions." Using a number of present-day examples Lyell sought to show that local alterations, say that from marsh to dry land, or fresh to brackish water, would never permit of slow organic change, because long before the organisms of the older environment could alter they would die out in competition with already adapted forms intruding to take advantage of the new conditions.

Lyell, in other words, could see how time and changing conditions might alter the percentages of living forms in given localities or change the whole nature of a flora. He understood that "the successive destruction of species must now be part of the regular and constant order of nature." What he still failed to grasp was that he was observing the cutting edge of the natural-selection process in terms of its normal, short-time effects. The struggle in nature that had so impressed him he had seen, if anything, too vividly. There was left no refuge, no nursing ground, by which the new could come into existence. The already created, the already fit, dominated every niche and corner of the living world. Lyell understood ecology before Darwin. He saw the web of life, but he saw it so tightly drawn that nothing new could emerge from it. As geographical or climatic conditions altered in the course of geological time, already existing forms moved from one area to another; he could see no evidence for a mechanism to explain the emergence of new forms.

His vision of the history of life was not wrong; it was simply incomplete. Lyell himself realized the complexities of the problem that beset him: There was a going-out without an equivalent coming-in, an attrition without a compensating creation.

"The reader will immediately perceive," Lyell wrote, "that amidst the vicissitudes of the earth's surface, species cannot be immortal, but must perish one after the other, like the individuals which compose them. There is no possibility of escaping this conclusion without resorting to some hypothesis as violent as that of Lamarck." Drawing back from this gulf, Lyell returns again and again to nonprogressionism. Nevertheless, like many naturalists of his day, he was willing to recognize "a capacity in all species to accommodate themselves, to a certain extent, to a change of external circumstances, this extent varying greatly, according to the species." Lyell

recognized minor varietal differences of a seemingly genetic character in some animals. Beyond this he did not venture.

The term natural selection, introduced by Darwin and now everywhere regarded as the leading mechanism in evolutionary change, has a peculiar history. Under other names it was known earlier within the century, but this is little realized. Darwin introduced the principle to his readers under a new term and with new implications so that it has been widely assumed that it originated in his mind. One might say, without minimizing Darwin's achievement, that this widespread impression is not quite accurate. Charles Darwin in reality took a previously recognized biological device and gave it a new and quite different interpretation. In doing so he opened the doorway to unlimited organic change and provided that empirical evolutionary mechanism which had driven Lyell and other objective scientists away from the progressionists, even though the latter had been correct, in a general sense, about the ascending complexity of life. Darwin's achievement was an apt illustration of what can sometimes be done with old principles when someone looks at them in a new way and sees some unexpected possibility within them. Darwin altered our whole conception of the nature of the world in which we live. He did so by making use of a principle already known to Charles Lyell and one other man, a young zoologist by the name of Edward Blyth. Essentially it was the principle that Lyell advanced against the evolutionary arguments of Lamarck in the 1830's.

Synoptical Table of Recent and Tertiary Formations.

PERIODS.		Character of Formations.	Localities of the different Formations.
I. RECENT.		Marine.	Coral formations of Pacific. Delta of Po, Ganges, &c.
		Freshwater.	Modern deposits in Lake Superior—Lake of Geneva—Marl lakes of Scotland—Italian travertin, &c.
		Volcanic.	Jorullo — Monte Nuovo — Modern lavas of Iceland, Etna, Vesuvius, &c.
II. TERTIARY.	1. Newer Pliocene.	Marine.	Strata of the Val di Noto in Sicily. Ischia, Morea? Uddevalla.
		Freshwater.	Valley of the Elsa around Colle in Tuscany.
		Volcanic.	Older parts of Vesuvius, Etna, and Ischia—Volcanic rocks of the Val di Noto in Sicily.
	2. Older Pliocene.	Marine.	Northern Subapennine formations, as at Parma, Asti, Sienna, Perpignan, Nice—English Crag.
		Freshwater.	Alternating with marine beds near the town of Sienna.
		Volcanic.	Volcanos of Tuscany and Campagna di Roma.
	3. Miocene.	Marine.	Strata of Touraine, Bordeaux, Valley of the Bormida, and the Superga near Turin—Basin of Vienna.
		Freshwater.	Alternating with marine at Saucats, twelve miles south of Bordeaux.
		Volcanic.	Hungarian and Transylvanian volcanic rocks. Part of the volcanos of Auvergne, Cantal, and Velay?
	4. Eocene.	Marine.	Paris and London Basins.
		Freshwater.	Alternating with marine in Paris basin—Isle of Wight—purely lacustrine in Auvergne, Cantal, and Velay.
		Volcanic.	Oldest part of volcanic rocks of Auvergne.

ROCK FORMATIONS of Recent and Tertiary periods were tabulated in first volume of *Principles of Geology*. Such tabulations showed the continuity of formations over a large area. Before the rise of historical geology local breaks in the continuity of rock formations had been taken as evidence that the history of the earth was a series of catastrophic events.

"Of all forms of mental activity," the historian Herbert Butterfield once wrote, "the most difficult to induce is the act of handling the same bundle of data as before, but placing them in a new system of relations with one another by giving them a different framework, all of which virtually means putting on a different kind of thinking cap for the moment." This is precisely what Charles Darwin did when he took the older conception of natural selection and by altering it a hairbreadth created that region of perpetual change, of toothed birds, footless serpents and upright walking apes in which we find ourselves. Yet difficult as Darwin's feat proved to be, he received a hint, a nudge as it were, which began with Lyell, was elaborated by young Edward Blyth and from him was apparently transferred to Darwin. No clearer sequence in the evolution of ideas can be perceived anywhere in the domain of science.

Edward Blyth was a man of 25 when he read Lyell and, impressed by his ideas, carried them a little further. In the British *Magazine of Natural History* in 1835 and again in 1837, the very year that Darwin opened his first notebook upon the species question, Blyth discussed what today we would call both natural and sexual selection.

"Among animals which procure their food by means of their agility, strength or delicacy of sense, the one best organized must always obtain the greatest quantity; and must, therefore, become physically the strongest and be thus enabled, by routing its opponents, to transmit its superior qualities to a greater number of offspring. The same law, therefore, which was intended by Providence to keep up the typical qualities of a species can be easily converted by man, into a means of raising different varieties."

This idea young Blyth referred to as his "localizing principle." Like Lyell he saw the conservative aspect of selection,

but he saw it more clearly. He actually discussed its genetic aspects. As the above quotation indicates, however, he interpreted natural selection as a providential device eliminating the variant and unfit and holding each organism to its divinely appointed place in nature. Nevertheless in the course of his speculations he draws up short before a startling thought. "A variety of important considerations here crowd upon the mind," he confesses, "foremost of which is the enquiry, that, as man, by removing species from their appropriate haunts, superinduces changes on their physical constitution and adaptations, to what extent may not the same take place in wild nature, so that, in a few generations distinctive characters may be acquired, such as are recognized as indicative of specific diversity. . . ? May not then a large proportion of what are considered species have descended from a common parentage?"

The great question had been asked again, but this time more definitively, more perspicaciously, than it had ever been asked before. Sadly, timidly young Blyth in the end rejects his own question. Like Lyell, from whom he had drawn much, he found the new world he had glimpsed too dim, too distant, too awe-inspiringly new to be quite real. One rubbed one's eyes and it was gone. The safe, constricted world of the English hedgerows remained—the world in which everything held its place.

But the year was 1837. Charles Darwin was home from the Galápagos, home from the five-year voyage of the *Beagle*, home with turtles and coral, bird beaks and pampas thistles in his head. He read the *Magazine of Natural History* consistently in this time. We know it from recently discovered evidence. In fact, Darwin, in a somewhat cryptic early letter, tells us so: "In such foreign periodicals as I have seen, there are no such papers as White or Waterton, or some few other naturalists in Loudon's and Charlesworth's Journal would have written; and a great loss it has always appeared to me." Loudon's and Charlesworth's Journal is the *Magazine of Natural History*. There, to lie undiscovered for a century, reposed the hint that seemingly started Darwin along the road to the *Origin*. There at last is the reason for the sudden burgeoning of his ideas after the return from the voyage. Interior evidence in Darwin's early essays strongly suggests the relationship.

Later on in the century the two men became friends. As to whether Edward Blyth ever saw or grasped the connection between his youthful thoughts and

the intellectual revolution that came in 1859, we do not know. After many years in India, where he devoted himself largely to ornithology, he was invalided home and died in 1873.

Passing from Lyell to Blyth to Darwin, the world faintly glimpsed by a few thinkers before them—that marred, imperfect and yet forever changing world which brings equally into being butterflies and men—dawns fully in our minds. If there is revealed to us the dark shadow of tooth and club by which we have arisen, we are taught also the utter novelty of life, its unguessed potentialities. The lost Eden which, as Francis Bacon had dreamed, might be repossessed by knowledge lies ahead of us, but it waits upon moral powers that may be as necessary to man as learning.

"Man is an ape and a beast," writes the pessimist. The true evolutionist will only say: "Man is a changeling. He is making himself blindly now, and dragging the dead past forward like a snake's cast-off skin whose fragments still bind him. He is a very young creature, a tick on Emerson's kitchen clock. Do not define him. Let the clock tick once more. Then we will know."

Already in Sir Charles Lyell's mind man's next hour was striking. As one surveys the long record of his life, as one sees his influence upon Edward Blyth, upon Darwin and upon Alfred Russel Wallace, as well as upon many other aspiring workers, one comes to recognize that to a major degree he set the scientific tone of the Victorian age. He brought to bear upon scientific thought and speculation a mind trained to the value of legal evidence. He was, on the whole, dispassionate, clear-headed and objective. By precept and example he transmitted that heritage to Darwin. He emphasized synthesis and logical generalization from facts. Both men eschewed small works and both amassed great bodies of material to carry their points. Lyell warned Darwin away from petty scientific bickering as a waste of time and nerves. At almost every step of Darwin's youthful career Lyell was an indefatigable guide and counselor. Then at that critical hour when Darwin was appalled by the reception of the news of Wallace's independent discovery of natural selection, it was Lyell and Hooker who counseled the simultaneous publication of the papers of both men.

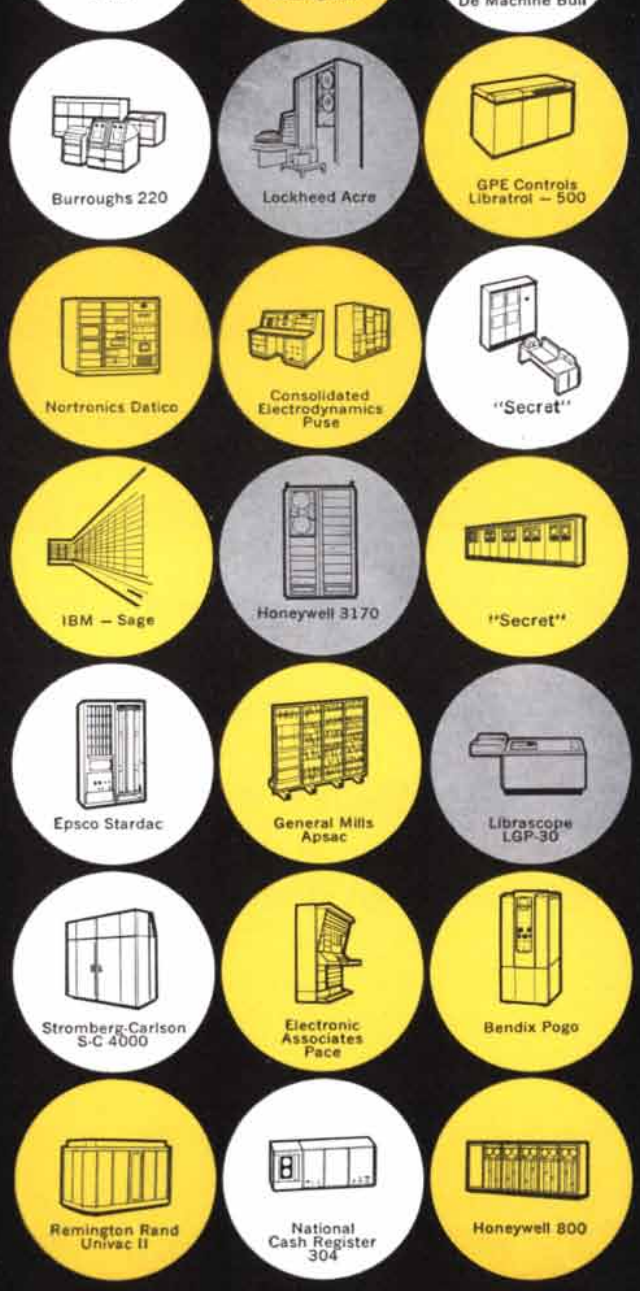
Darwin and Wallace were Lyell's intellectual children. Both would have failed to be what they were without the *Principles of Geology* to guide them. In science there is no such thing as total independence from one's forerunners. It is an illusion we sometimes like to foster, but it does not bear close examination. Even our boasted discoveries are often in reality a construct of many minds. We are fortunate if we sometimes succeed in fitting the last brick into such an edifice. Lyell himself knew this and tasted its irony.

He died in 1875 at the end of a long, outwardly uneventful life spent largely in the company of a beautiful, gracious and intelligent woman. After his wife's death in 1873 the light began to pass away from Lyell; he did not long survive her. A few years before, he had written to Ernst Haeckel: "Most of the zoologists forget that anything was written between the time of Lamarck and the publication of our friend's *Origin of Species*."

Much indeed had been forgotten. In this little sigh of regret Lyell was even then resigning his hold upon the public which had once idolized him. To the true historian of science, however, he remains the kingmaker whose giant progeny, whether acknowledging their master by direct word or through the lines of their books, continue today to influence those who have never heard his name.

Of Charles Lyell, Darwin himself said what is so often remarked in our day of Darwin: "The great merit of the *Principles* was that it altered the whole tone of one's mind and, therefore, that when seeing a thing never seen by Lyell, one yet saw it partially through his eyes."

CATASTROPHIC VIEW of the earth's history is reflected in this engraving by Albrecht Dürer. The engraving illustrates the passage in the Bible (*The Revelations of Saint John the Divine*, Chapter 6, Verse 13) beginning: "And the stars of heaven fell unto the earth. . . ."



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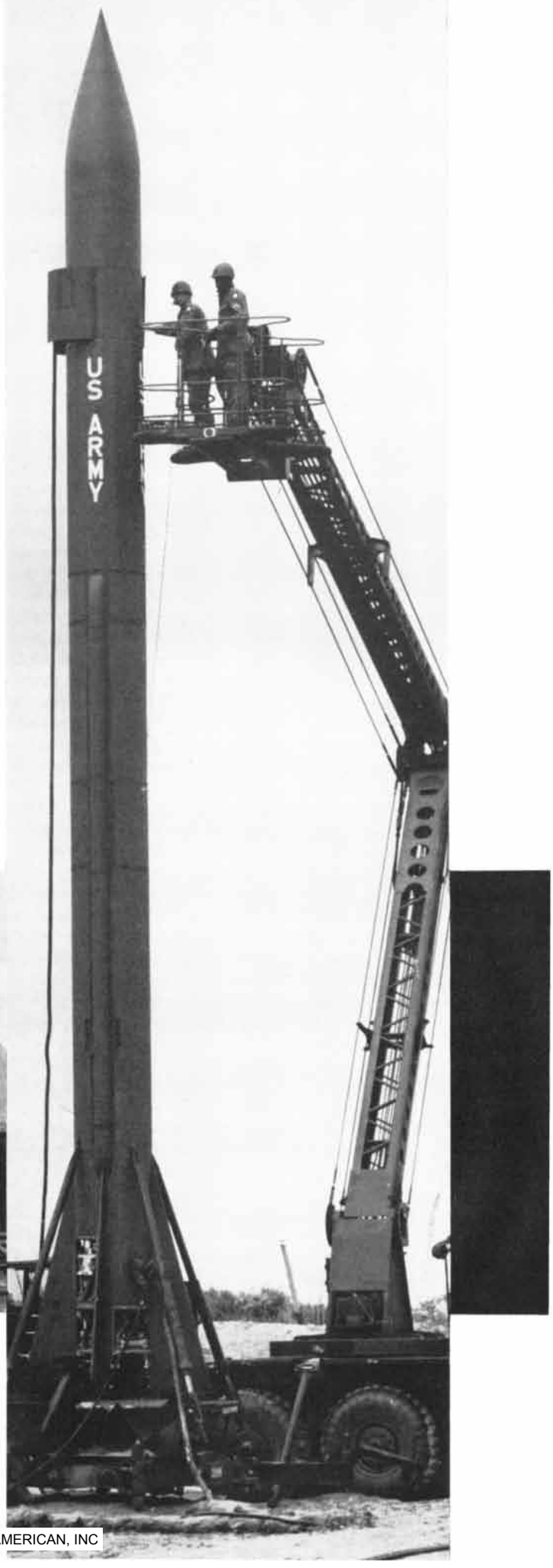

Technicians are carried to the "brain" of the Corporal missile on a "cherry-picker." Its boom is similar to that of an industrial crane. United States Steel representatives are constantly working with the manufacturers of cranes and power shovels to develop more efficient strength-weight ratios and better rigging.