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1902.

ORDINARY GENERAL MEETING.*

THE REV. F. A. WALKER, D.D., F.L.S., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed.

The following elections were announced :—

LIFE MEMBER :—William Arnold Hepburn, Esq.

MEMBERS :—Edgar Erat Harrison, Esq. ; Rev. William D. Fanshawe, M.A. ; Dr. John Hall Gladstone, D.Sc., F.R.S.

LIFE ASSOCIATE :—Miss Ella Smith-Bosanquet.

ASSOCIATES :—Lieut.-Colonel A. R. W. Sedgefield, M.B. ; The Rt. Rev. Dr. Lefroy, Bishop of Lahore ; The Rev. Arthur H. Ewing, M.A., Ph.D. ; The Rev. Henry Merwyn Tyrwhitt, M.A. ; Herr Frederick Waldemar Lönnbeck, Stockholm ; Rev. G. E. White, Anatolia College ; Clifford King, Esq. ; James Malcolm Maclaren, Esq., F.G.S.

The following paper, entitled, "The Preparation of the Earth for Man's Abode," was then read by the author :—

THE PREPARATION OF THE EARTH FOR MAN'S ABODE. By J. LOGAN LOBLEY, F.G.S., F.R.G.S., Professor of Astronomy and Physiography, City of London College.

INTRODUCTION.

A HUNDRED years ago the story of the earth could not have been told. Although the constellations had been devised, the heavens mapped, and the stars numbered and named, although the character and motions of the planets were known and the times of eclipses could be determined, although the globular form of the earth and its movements both of rotation around an axis and of revolution round the sun were well established facts, and although, moreover, gravitation had been discovered and Newton's *Principia* had been written and published, yet the structure of the earth was unknown. A century ago, the character and origin of the ground on which he trod and the formation of the rocks beneath his feet, man did not know, though cosmical theories had been advanced by a few learned men while the more extended knowledge which now enables us to give an

* Monday, 9th December, 1901.

incontrovertible account of the preparation of man's abode was not possessed by anyone, however learned.

Indeed, it is not too much to say that while some other sciences were advancing by leaps and bounds, terrestrial knowledge had made no headway until Hutton's *Theory of the Earth* was published. But after that epoch-making event, notwithstanding even then much strong opposition, geology advanced by rapid strides. It enlisted the enthusiastic love and devotion of some very able men; the Geological Society was founded,* as was also a Chair of Geology at each of our two great Universities, and Dr. William Buckland, afterwards Dean of Westminster, was appointed to be the first teacher of geology in the University of Oxford, and the Rev. Adam Sedgwick to the same position at Cambridge. The State recognized the substantial character and the utility of geological science by the creation of the Geological Survey of Great Britain and Ireland, and for half a century the truths revealed by geological investigation have been acknowledged and highly valued in every civilized country on the globe.

On previous occasions I have dwelt strongly on the educating power of geological knowledge and methods in different directions, and now I will venture to invite attention to its effective teaching of the unity of nature and the constant working of the processes of nature in one direction, that of progress towards the conditions at present existing on the earth, which are, in fact, the conditions under which man can live and develop his capabilities.

The record of the rocks is one of change—change world-wide and change continuous. But if it be a record of incessant change, it is also a record of persistency of direction to which the work performed by that incessant change points. For all the changes revealed by geological investigation are but steps in the great march of cosmical events towards the production of present terrestrial conditions. And as these conditions allow not only of the life of mankind, but also of the increase and physical development of humanity and of the mental and moral growth of the human being, we must conclude that all geological changes, which include palæontological or ancient zoological changes, have been the necessary steps for man's existence on the earth. After referring to the analogies between the

* By Mr. George Bellas Greenhough, F.R.S., in 1807.

three living genera of Crustacea—*Serolis*, *Limulus*, and *Branchipus*—and the trilobites of palæozoic times, Buckland, in his *Bridgewater Treatise*, writes: "When we see the most ancient trilobites thus placed in immediate contact with our living Crustaceans, we cannot but recognize them as forming part and parcel of one great system of creation, connected through its whole extent by perfect *unity of design*, and sustained in its minutest parts by uninterrupted harmonies of organization."*

The story of the earth has been the subject of many voluminous works, so great is the accumulation of the results of the observations and researches of geologists in many lands. It will be obvious, therefore, that in a single paper nothing more can be attempted than a very general summary of the wonderful story, which can deal only broadly with the great teachings of the records of the rocks.

These records, clearly, distinctly, and even conspicuously, tell of progression throughout a vast period of time, as the result of agencies of nature working ceaselessly and unchangingly, yet with results differing in magnitude and intensity in different regions and at different epochs, but all the consequence of laws that know no change. Thus, although what is commonly called uniformitarianism in geology has been displaced by the present evolutionary geology, even as uniformitarianism displaced catastrophism or convulsionism, every geologist is and must always be a uniformitarian with respect to the ultimate causes of the building up, and of the sculpturing and conditioning of the present surface of the globe.

Three Periods.

The existence of this planet may be said to have extended through three periods, the first of which is hypothetical, the second consequential, and the third historical, since its history has been written in language both clear and unimpeachable; the universal language of the records of the rocks.

The First Period saw the aggregation of the matter of the earth; its fused and intensely heated condition; its assumption of the globular form; its revolution around a great overmastering attracting body, the sun; its rotation

* "Geology and Mineralogy considered with reference to Natural Theology" (*Bridgewater Treatise*, vol. i, p. 394).

around a constant axis, and its consequent deviation from the spherical to the spheroidal figure; and, subsequently and finally, the loss of one-eightieth of its bulk by the separation by centrifugal force of its equatorial, exterior, protruding portion, with the resulting formation of the moon.

The Second Period saw the solidification of the exterior by cooling, the *consistentior status* of Lord Kelvin, by which the first permanently solid rocks of the globe were formed; the furrowing or wrinkling, and local depressing of the surface by shrinkage; the cooling of the hot and heavy vaporous atmosphere, with the consequent condensation of the water-gas (H_2O); the gradual filling of the surface hollows with the water so condensed, and the consequent formation of the primæval seas and oceans of the globe; also the commencement of the destruction of the first-formed land by the continuous and heavy rain highly charged with acids, and the transportation of the eroded material and its deposition beneath the waters of the first-formed seas. Thus would be accumulated vast thicknesses of sedimentary rocks to be afterwards melted by interior heat or transformed in character by metamorphosing agencies.

The Third Period saw the commencement of organic life following on the establishment of the necessary normal atmospheric and land conditions. With variations of temperature between 32° F. and 212° F., winds would be produced, with evaporation and precipitation of water, that would give rise to storms, rain, and rivers, and so denudation and the formation of sedimentary rocks would be continued. The earlier of these rocks would also afterwards be largely metamorphosed and any organic remains entombed in them obliterated; but they are the foundation stones of the vast pile of stratified and fossiliferous rocks of later ages.

This Third Period, therefore, witnessed the accumulation of the stratified rocks and the innumerable generations of animals which have successively inhabited the globe, with the introduction of higher and higher forms, or organisms of greater and greater complexity; and witnessed, too, the production of those great physical features of mountains, valleys, and variously indented coast lines which now diversify the land areas of the globe. And along with all this animal life and these geological results, there was the growth of plants, at first lowly cryptogamic organisms, and afterwards lordly forest trees and the vast variety of phanerogamic vegetation which now clothes and beautifies the surface, for this period has seen all the geological and biological changes that have been in progress up to the present time.

It is to this period that modern geology has almost confined its attention. But geology has now taken a wider view of its scope and functions, and in doing so it approximates to the etymological meaning of the word geology, as the science of the earth; for it embraces all that can be taught respecting the earth as a whole, its relation to the sun, to the other planets, and to its own satellite, as well as its structure and the changes to which that structure is due. All terrestrial knowledge is, in fact, within the scope of geological inquiry.

It is, however, the Third Period, of which the earth has preserved for our instruction copious records in the great stone-book of nature, to which I must now necessarily confine myself.

From all analogy, I think it is fair to conclude that each of the two previous periods had a very long duration. Lord Kelvin is, however, of opinion that when the solidification of the exterior of the globe was consummated, the surface rapidly cooled and soon became fitted for the existence of organic life.

But whatever was the duration of the First and Second Periods, there can be no hesitation in concluding that the Third Period was one of prolonged duration.

The Records of the Rocks.

Rocks which are obviously sedimentary, or composed of material worn away from other rocks—clastic rocks, as they are termed by geologists—occur much lower than the oldest Cambrians, for they form large masses amongst the pre-Cambrian or Archæan rocks.

The Cambrian rocks, however, have preserved the hard parts of animals inhabiting the seas of the period so admirably that not only the lower sub-kingdom, Hydrozoa, but the much higher classes, Crustacea, Brachiopoda, and Lamellibranchiata, are clearly shown to have been both in existence and to have been well developed and abundantly represented. Some of these ancient rocks are conglomerates, or beds of cemented shingle, each pebble of which was rounded by the rolling action of sea-waves, exactly as is going on now at Brighton.

In the rocks that were formed after the Cambrian, namely, the Lower Silurian, we find remains of higher Mollusca than those in the Cambrian rocks, for there are fossil gasteropods, pteropods, and cephalopods, some in great abundance. The trilobites and brachiopods of the Cambrians become more numerous and more differentiated so as to give many genera of these groups. The Lower Silurian rocks include limestones, slates, and shales, telling of tranquil waters; and thick masses of volcanic rocks, both consolidated fragmentary ejectamenta, or ashes, and compact basalts, telling of violent eruptions and great lava flows, such as we have at present.

The inorganic conditions, therefore, of the Cambrian and Lower Silurian epochs cannot be said to have been greatly dissimilar to those of the present time, and consequently we must look chiefly to the organic worlds of plants and animals to find the changes that chiefly prepared the earth for man's existence and abode.

A great step in this wonderful progressive march is indicated by the fossils of the next great division of the sedimentary rocks, the Upper Silurian, for these rocks reveal the appearance on the globe of the highest sub-kingdom of animals;—the Vertebrata, since in them are the remains of fishes—true fishes certainly, but of an early type only. Their most conspicuous difference from the usual fishes of the present seas is the form and character of the tail, to the extremity of which the back-bone extended, giving it a prolonged pointed form. These herocercal-tailed fishes, as they are called, have still many representatives in the sharks, sturgeons, and skates, but they are now less numerous than the homocercal or equal-lobed-tail fishes which are now so common and abundant. In Silurian rocks, too, are remains of undoubted land plants, which Sir William Dawson described as *Prototaxites*, but now called *Nematophyton*, which was probably a thallophytalform.

The Devonian epoch saw a considerable development of Vertebrata, as the fishes were numerous, and though retaining the vertebral tail, diverged from the pristine type and approximated to the modern salmon-like form. Large crustaceans very much larger than our present largest species, the giant Australian crab, abounded. One of these, a *Pterygotus*, in the Geological Museum, Jermyn Street, measures 4 feet in length. As the beautiful Devonshire marbles conspicuously show, reef-building corals worked as industriously as now. In this period, too, there was a great development of plant life, both aquatic and terrestrial, including amongst the land plants lycopods, equisitaceæ, rhizocarps, and an abundance of true ferns, *Filices*, vascular spore-bearing plants, amongst the highest of the cryptogams. When the little likelihood of land plants being included and preserved in marine deposits is borne in mind, we cannot wonder that the far more ancient plants of Cambrian times (if such there were) have not yet been met with to give us examples of the lower steps of our terrestrial flora.

A further advance is distinctly seen when the Carboniferous rocks are examined. Comprising, as they do in some places, fully 3,000 feet thickness of limestone, what a wonderful amount of animal life is proclaimed! For this is a marine deposit, and so has been produced by the accumulation of material secreted by animal forms as solid matter to form their endo- or exo-skeletons. Innumerable examples of the beautiful structures built up of this organically converted solid matter have been perfectly preserved in the crinoidal, shelly, and coralline limestones of Derbyshire and other localities, which are well-known objects in our museums. In Carboniferous rocks, too, there is evidence of the appearance on the globe of a class of vertebrates higher than the fishes of the Devonian rocks. This, the Amphibia, is represented by the order *Labyrinthodontia*. The Amphibia, or Batrachia, best known now by our frogs and toads, are intermediate between fishes and reptiles. Insects of several orders seem also to have abounded.

But it is the wonderful preservation of the produce of plant-growth that gives to the Carboniferous rocks their greatest interest and their chief value to man. The coal seams in these rocks are but consolidated masses, or beds, of vegetable matter grown on land or, at least, on swampy areas. This enables us to ascertain the biological level to which plant forms had attained in the Palæozoic epoch. It also shows that the climate then prevailing over a large portion of the earth's surface was warm, or at least very mild; for the vegetation in temperate regions was as profuse as it is at the present day in the forests of the Amazon and other tropical river valleys. Nor were the Carboniferous forests wanting in stately, arborescent forms, for lycopods attained a large tree-like size in *Lepidodendron*, and in *Sigillaria* grew to a girth of 16 feet and a height of 50 to 60 feet. Equisitaceæ gave the genus *Calamites* in great abundance, while the ferns were most profuse in the great number of genera and species, some of which are remarkably similar to those now growing so freely in the southern counties of England.

The Carboniferous rocks and their contents are of the greatest value to mankind and most conducive to the progress and advancement of humanity; and as to our own country, it may be said that Great Britain owes its wealth, power, and importance in a great degree to the beds of coal contained in the rocks of this period.

Of the various substances, all most useful to man, and stored up for his use in the Carboniferous rocks, the most important is coal, which for two hundred years at least has been abundantly employed for giving heat, light, and power to mankind. It occurs in very large and widely separated areas, for it is found in both the Old World and the New, and in both the Northern and the Southern Hemispheres. Yet great and extensive as are the coal-beds of to-day, they have been much more extensive in the past, for very large areas have been swept clear of the coal they once possessed by the agency of denudation.*

Although the conditions prevailing in the regions in which the known Permian rocks were deposited were unfavourable to animal life, with the result of giving to those rocks a diminished fossil fauna, yet the comparative abundance of amphibian forms is evidence of continuous progress towards present terrestrial conditions. The epoch was intermediate between Palæozoic and Mesozoic (or Secondary) times, between the age of Invertebrata and of fishes and the age of reptiles, birds, and mammals. The flora had a quite Carboniferous character, ferns being abundant and tree-ferns numerous. In addition there were some phanerogams, though confined to the gymnosperms, as remains of cycads and conifers are found in rocks of Permian age.

As in the older so in the later Palæozoic ages, volcanic

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* This is especially the case in the case of Ireland, the whole of the central plain of that country having been originally covered by deposits with coal.—ED.

outbursts added igneous rocks to the sedimentary deposits, and so contributed to the picturesque beauty and varied elevation of many localities at the present time. Many of the hills of the south of Scotland, including the well-known Arthur's Seat and the Castle Rock at Edinburgh, owe their existence to the eruptions of volcanoes in Carboniferous times, as does the marvellous scenic beauty of the Cumberland Lake District to volcanic action in Lower Silurian times.

It should be added that the Palæozoic rocks as a whole form a vast store-house, as it were, of economic minerals available for man's use at the present time. Amongst the treasures which they contain, in addition to those peculiar to the coal-measures, are gold, silver, copper, mercury, lead, platinum, zinc, and antimony. These ancient rocks, too, by their general hardness and consequent greater resistance to denuding agencies, have added great beauty to the world, and so have in this way also contributed much to the happiness of mankind. The most picturesque and beautiful scenery is in regions where the Palæozoic rocks occur, forming as they do mountains and hills, deep valleys, lakes, and irregular coast-lines with lofty and precipitous cliffs.

The Secondary rocks continue the record of change and progress. Very many of the life-forms of the older rocks are absent, and thus tell us of the extinction of a great number of species and genera and of some large groups. The most noteworthy is the extinction of the entire group of trilobites, which were most abundant in Silurian times. These very well defined crustaceans ranged in time from the Lower Cambrian to the Carboniferous epoch.

Although the oldest of the three great divisions of the Secondary rocks, the Triassic, is not, as a whole, well adapted for containing organic remains, since the Triassic rocks are largely formed of sandstones, yet one series of strata, the Rhætic, has been sufficiently preservative to yield decided evidences of a striking and most important advance in animal organization; for in these beds are remains of an animal in the highest zoological class, Mammalia. The *Microlestes antiquus* was a small animal of one of the lowest orders of the class, Monotremata, yet it was unmistakably a mammal, and thus the highest class of the animal kingdom is found to have been represented in early Secondary times.

In the varied and highly fossiliferous Jurassic formations, the rocks were formed during an epoch which has been called "the Age of Reptiles" from the dominance of the large marine and the gigantic land reptiles which then peopled the globe. The enormous and terrible Dinosauria is an extinct order of Reptilia;—our present largest reptile, the crocodile, having a femur only one-sixth the length of the femur of a deinosaur. Another most remarkable extinct order, the Pterosauria, flourished in Jurassic times. These extraordinary creatures were winged reptiles, the wings having a range of extension up to 24 feet. Although the wings were bat-like and not feathered, the pterodactyles had some of the characters of birds in conjunction with some that were reptilian. The remains of a true feathered bird, however, have been found in these rocks, showing that all the classes of Mammalia were in existence in the Jurassic epoch.

One feature of the Secondary fauna is too remarkable to be here omitted. It is the incoming, enormous development of, and then the extinction of, two well defined groups of the class Cephalopoda, the ammonites and belemnites. Along with the ammonite flourished the nautilus, of the same order of Cephalopoda, the Tetrabranchiata, yet in Palæozoic times the nautilus lived when there were no ammonites, and the nautilus still flourishes, while the ammonite ceased to exist at the close of the Secondary epoch.

With the exception of the Old Red Sandstone and the coal seams with their underclays and shales, the rocks known to us up to the Jurassic series are, from their fossils, obviously marine. But some of the beds of the lower oolites are estuarine in origin, and they contain a large assemblage of land plants, in some cases beautifully preserved, which afford an indication of the character of the terrestrial flora of Jurassic times. From these fossil plants and parts of plants it is seen that this was an epoch of gymnospermous phanerogams. The prevailing order was Cycadaceæ, about twenty genera of cycads having been described from Jurassic rocks, and the conifers were represented by the genera *Araucaria*, *Pinites*, *Thuytes*, and others.

The Cretaceous rocks furnish a most interesting connecting link with the present, since their most remarkable division, the chalk, is a rock of the same character and composition as a deposit now forming on the floor of the Atlantic Ocean. Even some of the species of the microscopic shells of which it is made up are the same in both cases, and one, the *Globigerina bulloides*, is abundant in both the Cretaceous beds and the Atlantic ooze of the present day.

The fauna of the Cretaceous rocks is noteworthy as well for what it lacks as for what it includes. One of its *lacunæ* is the absence of mammalian remains in the European area, with the exception of a species ascribed to the genus *Plagiaulax* found at Hastings. Fishes of the highest type, the *Teleostei*, now make their appearance, and one genus, the *Beryx*, is not uncommon in the chalk of Surrey and Sussex. Of the Reptilia, the great Jurassic deinosaurs, although in some abundance still, die out with the Cretaceous epoch, and the same may be said of the pterosaurs. The Cretaceous reptiles have left some remarkable examples for our instruction. Amongst these are the gigantic three-toed *Iguanodon Mantelli* of Sussex and Kent, and the still larger *Iguanodon Bernissartensis* of Belgium, which have been made well known by our museums; and the pterodactyles of the Cambridge greensand. But it is to the rocks of the Western States of North America that we owe the greatest exposition of the reptilian forms of the Cretaceous epoch. From these rocks have been obtained many species of deinosaurs, pterosaurs, crocodiles, marine saurians, turtles, and no less than fifty species of veritable sea-serpents, of which the enormously long *Mososaurus* is best known. These dominating monsters of the Cretaceous seas were some as much as 75 feet long.

Although birds do not live under conditions favourable for the preservation of their bones, some remarkable species have been entombed in Cretaceous rocks, chiefly in North America. One group, Odontornithes, was toothed, and in the genus *Hesperornis* the teeth were in a common alveolar groove as in the reptilian *Ichthyosaurus*. Thus some of the birds of the Cretaceous epoch had affinities with the then dying out reptilian groups of deinosaurs and pterodactyles. In America, too, in the Cretaceous rocks of Dakota and Wyoming, a large assemblage of mammalian remains have been discovered. These have been placed by Professor Marsh in sixteen genera, but all are of the lowest orders of Mammalia and allied to the Jurassic forms of the same class.

A very important advance in plant-life marks the Cretaceous epoch, for in its rocks are the remains, often beautifully preserved, of the earliest known angiosperms.

which give to us at the present day our highest forms of the vegetable kingdom, and with these the phanerogams are also represented abundantly by the gymnosperms that marked the Jurassic epoch. From Westphalia alone fifty-three species of dicotyledonous angiosperms have been obtained from Upper Cretaceous beds. These include species of, amongst other genera, *Quercus*, *Populus*, *Eucalyptus*, and *Ficus*. In the Cretaceous rocks of other parts of Germany the phanerogams are represented by the genera *Acer*, *Salix*, and such conifers as *Sequoia* and *Pandanus*, the screw pine.

Another very remarkable feature of the Cretaceous flora is its extension, and in great abundance, to the Arctic Regions, where, in North Greenland, are found remains of oak, walnut, plane, laurel, ivy, ilex, and even magnolia and eucalyptus. Again, in the Uppermost Cretaceous of North America, the Laramie formation, one hundred species of dicotyledons have been discovered, amongst which the vine (*Vitis*) is especially to be noted. The Potamac formation of Virginia and Maryland furnishes, besides, about three hundred and fifty species of conifers, cycads, and lower groups, and seventy-five species of angiosperms, including the genera *Sassafras*, *Ficus*, *Myrica*, *Bombax* and *Aralia*.

The epoch, therefore, during which the Cretaceous rocks were deposited not only witnessed the existence of the highest class of animal life, Mammalia, but also saw clothing the earth the highest division, the dicotyledons, of the highest class, the angiosperms, of the highest sub-kingdom of plants, the phanerogams, or in other words the highest group of plants known to man.

The stores of mineral treasures in the Secondary rocks, although not so vast and important as those in the Palæozoic rocks, are yet very great. These rocks contain large amounts of copper and iron ores, and gold has been obtained from the Cretaceous rocks of North America. Alum and gypsum are other substances useful to mankind which these rocks supply, and building stones, both limestones and sandstones, are very largely obtained from Secondary rocks, as well as the more ornamental marbles and alabasters, and various useful sands and clays. But their most noteworthy product is perhaps rock-salt, occurring in beds of great thickness and resulting from the drying up of lakes and shallow seas usually in Triassic times, but some in the Jurassic epoch.

In the Tertiaries, the latest of the main subdivisions of the sedimentary rocks before that containing undoubted evidences of the advent of man, we read the records of the consummation of the preparation of an abode for man. Physical changes will of course continue, but we have no reason to suppose that new forms of life will appear.

The most striking features of the work of Tertiary times are (1) the production in the rough, if I may so say, of those great modellings and sculpturings of the land that now diversify its surface, and (2) the great development of the highest organic forms, both animal and vegetable.

The elevation of great mountain ranges, mountainous regions, and plateaux, though not of all, the cutting of river-valleys, the spreading out of great low plains, the formation of lakes, the separation of islands from the large land masses, and the production of coast lines, as we now know these geographical features, were in the main the work of the Tertiary epoch. Some, it is true, of the great surface features of the earth have a much older date, and, on the other hand, considerable modification of the features of Tertiary geography has been accomplished by the unceasingly acting agencies of nature, operating geologically all through the by no means short Quaternary epoch quite up to the present time. But it is still true that the present physical features of the land were, in the main, the work of Tertiary times.

Miocene rocks occur at an elevation of 5,000 feet in the Alps, and Pliocene strata are found as high as 14,000 feet in the Himalayas. To elevation during the Tertiary epoch is due the chief part of the height of the Andes in South America; and the Rocky Mountains in North America, in which Cretaceous strata are now 14,000 feet above the level of the sea, may also be termed Tertiary mountains, although part of the elevation has taken place in both older and newer epochs.

In the British Islands the work of geological agencies in the Tertiary epoch has left very conspicuous results. In the Isle of Wight Cretaceous and Lower Tertiary strata are now so far altered from their original horizontal position as to be absolutely vertical. The denudation of the chalk has been so great that although from its protective covering of basalt the chalk has been preserved in the North of Ireland, all the part that once was continuous to the chalk of Sussex has been swept away except that to the south-east of a line from Dorset to Flamborough Head, and in this area the greater portion has been destroyed. When it is remembered that the chalk has a total thickness of over a thousand feet, the denuding agencies that have destroyed so much of it will be at once seen to have produced most important changes of surface in Tertiary times.

In the south-east of England, where we now are, the chalk extended over the whole of the Wealden area, connecting the North Downs of Surrey and Kent with the South Downs of Sussex. The pebbles constituting the Oldhaven Beds, 40 or 50 feet thickness, and forming still a large area in West Kent and East Surrey, are cogent evidence to everyone walking over Blackheath or Croham Hurst of the enormous destruction of chalk that took place in early Tertiary times, for these beds are of Lower Eocene age, and every pebble is a highly finished, well rounded fragment of a chalk flint.

Of the geological work and consequent geographical changes accomplished during the Tertiary epoch, Sir Archibald Geikie says: "The Tertiary periods witnessed the development of the present distribution of land and sea and the great mountain chains of the globe. Some of the most colossal disturbances of the terrestrial crust of which any record remains took place during these periods. Not only was the floor of the Cretaceous sea upraised into low lands with lagoons, estuaries, and lakes, but throughout the heart of the Old World, from the Pyrenees to Japan, the bed of the early Tertiary or nummulitic sea was upheaved into a succession of giant mountains, some portions of that sea-floor now standing at a height of at least 16,500 feet above the sea."*

The great development of the highest organic forms which, as has been said, also distinguished the Tertiary epoch is abundantly testified to by the records of the Tertiary rocks. The highest group of plants we have seen was well developed at the close of the Secondary epoch, but in the animal kingdom only the orders Marsupialia and Monotremata, of the class Mammalia, were represented, so far as we know, at that time. In the Tertiary formations, however, the fossils introduce us to higher and higher species, until in its latest strata forms are found almost identical with species of the highest existing orders.

From the Eocene beds of the Paris Basin remains have

* *Text Book of Geology*, 3rd edit., p. 963.

been obtained of a number of species of birds which include forms allied to our living pelican, flamingo, quail, and hawk. And in these beds is the first appearance of the higher orders of Mammalia, but the earlier species, although carnivores, have affinities with the marsupials, and then occurs the bones of the *Hyracotherium*, a small pig-like animal with canine teeth.

The Upper Eocene beds, now called Oligocene, both of the Paris Basin and the Isle of Wight, have given a rich assemblage of mammalian bones. Baron Cuvier in France and Professor Owen in England worked at these bones with such success that they both arrived at the same conclusions, which established their accuracy. Thus *Anoplotherium*, *Palæotherium*, *Xiphodon*, and other genera of the order Ungulata were added to the fossil fauna of France and England. The *Anchitherium* was intermediate in structure between the tapir-like species just named and the horse. It was as large as a small pony, but had three toes. With these, the earliest allied form to monkeys, the *Cœnopithecus*, appears, and hornless deer and antelopes seem to have been numerous in the Eastern Hemisphere.

In Miocene times, what is now Great Britain was probably a land area and so contains no deposits of this age. But Central Europe was then under water that extended along the line of the Alps, not yet raised to their great elevation, and the Pyrenees, and during the Miocene epoch marine gradually changed to brackish water conditions in this central sea. The result has been the accumulation of enormous deposits in Southern Europe and the basin of the Mediterranean, and the entombment of a magnificent assemblage of organic remains that presents us with a very vivid picture of at least the flora, if not of the fauna, of Miocene lands.

The fauna is, however, sufficiently illustrated to show that it differed considerably from that of the Oligocene epoch. We now find the earliest elephantine animals in the great mastodons, and with these there was an enormous ant-eater, the *Macrotherium*; an early pig, the *Hyotherium*; a sabre-toothed tiger, the *Machairodus*; and a bear with affinities with the hyæna, the *Hyænarctus*. According to Gaudry, the first anthropoid ape, the *Dryopithecus*, appears; but Owen thought it was more allied to the gibbons. In America, deposits of Miocene age have given the large *Brontotherium*, which is distinct from any existing family, but is nearest to the rhinoceros. The Miocene fauna is especially interesting from its giving to us the remains of the earliest dogs and camels. The genus *Canis*, of the Upper Miocene of Œningen, is related to the *Hyænarctus* already mentioned. The *Protolabis*, of the Miocene of North America, is regarded by some as the earliest camel, but the *Procamelus* of rather later deposits, though still Miocene, is nearer to our present camel.

The leaves of the forests of the surrounding lands have been beautifully preserved by the deposits in Miocene lakes, and they have been carefully described and illustrated by Professor Heer, of Zurich. The flora as a whole indicates a subtropical or warm climate, becoming colder towards the close of the epoch.

In the Miocene flora there are remains of representatives of families of plants that have for a long period been of great use to mankind for fruit, for flowers, and for timber. Of fruit trees both *Pomaceæ*, giving us our apples and pears, and *Amygdalaceæ*, giving our almonds and plums, appear, the former in *Pirus*, pear, and the latter in both *Amygdalus*, almond, and *Prunus*, plum. *Rosaceæ*, *Violaceæ*, *Papilionaceæ*, and *Ericaceæ* added floral beauty to the Miocene forests as they now do to our gardens. Of forest trees we find that the following genera, which were of earlier introduction, were in great abundance:—*Quercus*, *Ulmus*, *Platanus*, *Acacia*, *Acer*, *Ilex*, *Sequoia*, and *Mimosa*. The flora also included *Magnolia*, *Betula*, *Laurus*, *Myrtus*, *Ficus*.

We have at length reached the epoch immediately preceding the advent of man on the earth, the Pliocene or latest of the Tertiary periods. The approach to present conditions, both in the animal and the vegetable kingdoms, is very conspicuous. Deposits of this age are not wanting, in the east of England, showing, therefore, a depression of this area beneath the waters of the Pliocene sea, but they seem to have attained their maximum importance in Italy and Sicily where they have a thickness of 1,500 feet.

The Miocene *Deinotherium* and *Mastodon* still lived, but they were now being supplanted by the true elephant, the rhinoceros and by the hippopotamus, and a large number of other herbivora allied to antelopes, deer, etc., indicating large grass-covered areas, together with the giraffe-like *Helladotherium* and *Samotherium*, and the Sewallik Hills of India give to the Pliocene fauna the *Sivatherium* and the

Bramatherium. Now we find the true horse, *Equus*,* and along with it the *Hipparion*, now extinct, which had three toes, but only one, the middle one, touching the ground. Now, too, we have the ox, with the cat, the hare, and the mouse. The *Mesopithecus* and the *Dolichopithecus* were the apes of the period.

The flora of the Pliocene epoch was very similar to that of the present day in England, with the addition of one or two subtropical plants, and towards the end of the period the plants requiring most warmth disappeared, indicating a lowering of the temperature and an approximation to present climatal conditions. Besides the present forest trees of England, we find the buttercup, chickweed, dock, sorrel, marsh marigold, the *Osmunda regalis*, and many other plants with which we are familiar.

Although at the commencement of the Quaternary or Human epoch the climate in this and more northern regions was undoubtedly too rigorous for man, yet in more southern latitudes, to which the ice-covering conditions of the Glacial epoch did not extend, there would be no climatal hindrance to his existence. On the return of more suitable climatic conditions, man was undoubtedly living in these and adjacent areas. Judging from the large number of flint implements found in the Pleistocene gravels of England and France, man seems to have been tolerably abundant in the European regions soon after the departure of glacial conditions.

Since that time, favouring conditions for man have continued to increase, and profiting by these, man has made advances, and by these advances has aided the progress of favouring conditions. But with the preparation of the earth for the earliest man, the simple human being, we have had alone to do, and the changes that have taken place during the Quaternary epoch are not, therefore, within the scope of this essay.

Conclusion.

The records of the rocks which have now been presented, although briefly and quite disproportionately to the greatness

* The *Equus asinus*, the ass of East Africa, has left its remains in the Pleistocene cave deposits of India, though not now living there.

of the subject, will be sufficient, I hope, to clearly show that present terrestrial conditions are the result of innumerable links in a chain of events extending throughout a vast period of time, and that every one of those links was necessary for its successor; and that therefore all have been concerned in the preparation of man's abode.

Even the vastness of the time has been a most important factor in producing phenomena of every-day observation. For to it is due the great range of the character of the rocks, the extreme hardness of some and the softness of others, which give to us now our mountains and our vales.

The composition of the original rocks has been the source of all we find of value to mankind in the present crust, and the various geological changes that have taken place have given variety to the rocks now at the surface, furnishing the soils suited to the production of all that the varied wants of man require. Regions we have for mining minerals, regions for forest growths, areas for the growth of the plants that give us food and all the many valuable products of the vegetable kingdom.

These plants, too, and the animals useful to man, have been the ends of series contemporaneous with the geological changes, and therefore part of the preparation of an earth suitable for the habitation of man by the Creator.

Still further may we say that the means of communication by water, the seas and rivers of the globe, by which mankind can intermingle, spread the products of the land, learn and progress, and subdue the earth, have also been the result of the changes of the past. Nay more, beauty and variety of landscape, beauty of field and flower, and even the charm of the music of the birds, have all been the outcome of this wonderful preparation extending throughout geological time.

Discussion.

The Chairman.—I think you have already anticipated what I was going to propose, viz., a cordial vote of thanks to Professor Lobley for his interesting and instructive paper, dealing with so many products of the past and present world, showing us the links between the two and the successively higher forms of organic beings and the times at which they appeared. We shall be pleased to hear any one who would like to speak on the subject or to put any questions to the author.

The SECRETARY (Professor HULL, LL.D.).—Mr. Chairman,—At my suggestion Professor Logan Lobley kindly undertook to deal with the subject of his essay. It is one which, as it seems to me, is eminently suited for the consideration of members of the Institute, and I feel sure it will be allowed that it has been ably handled by the author.

It is one of the great triumphs of Science of the nineteenth century, and of the Victorian Era, that it has witnessed the unfolding of the Geological Record. For nearly eighteen centuries of the Christian Era, not to speak of the many previous centuries, mankind had no other guide to his knowledge of what we may designate "the pre-Adamic history of the world and its inhabitants" beyond that afforded by early chapters of the Book of Genesis. I am not here to disparage the geological record as contained in that wonderful book, which I never read, or hear read, without recognizing that it is far beyond what unassisted human reason could have imagined or produced at the time it was written. It contains in simple and stately language the main outline of the history of the world and of its inhabitants; but it was left for recent scientific investigation to fill in the details, and so complete the record. That has been the great work of the nineteenth century; and the author has unfolded it to us this evening, briefly as was necessary, but with sufficient fulness to enable us to recognize the grand procession of vital phenomena—the development of animal and plant life, of which the earth has been the theatre—from the earliest dawn to the present period.

The portion of the essay which will cause most interest is probably that in which we approach the appearance of the animals and plants now inhabiting the globe, and which ranges through the Tertiary period. There we have the process of organic evolution by which the forms more and more approximating to those now inhabiting the world appeared in company with man himself. It was a slow and gradual process, as are all the great events of Providence in the affairs of the world; in His plan for the government of the world there must always be "the fulness of time"; and in the natural world we know that it is governed according to the proverb "*Natura nil facit per saltem.*" Thus when the time arrived those forms of animal life appeared which were destined to minister to man's physical wants as well as to his advance in civilization. Along with them came the forms of plant life specially adapted for sustenance, as well as to adorn and beautify the face of nature, and so minister to his mental enjoyment. At last man himself appeared on the scene—the last and most perfect of all God's works, equipped with powers and faculties suited to enjoy the great gifts placed within his reach, and with mental powers capable of investigating the laws which govern the universe. For him the whole world is a Garden of Eden ; for him, every habitable portion is furnished with animals and plants suited to minister to his wants. Surely, in all this we may see clear and unmistakable evidence of design and adaptation, illustrating the striking passage of the Psalmist, " The heaven, even the heaven is the Lord's, but the earth hath He given to the children of men," given as his school for training in the knowledge of God and of His works, and of His purposes of love, in preparing us for a still higher state of bliss.

The Rev. JOHN TUCKWELL, M.R.A.S.—I should like to follow what our Secretary has just stated in regard to the wonderful agreement between the first chapter of Genesis and the paper which we have listened to. Every one well remembers the first verse of that chapter, which states a very remarkable and universal fact, and that is, that it was God who created, in the beginning, the heavens and the earth. But if you look carefully into the chapter, I think it will be found that those stages are delineated in the chapter. Take the statement of the story of the earth in particular—that "the earth was without form and void." Now as the Septuagint was translated, that expression "without form" is "invisible," and the word "void" indicates an unfinished state. What could more fitly represent the chaotic condition of our globe than such a word? A globe of gas would be without form and without those objects that are now around us.

Now in the next stage you have the statement that "darkness was on the face of the deep." That is a remarkable expression.

In an address given before this Society some years ago by Lord Kelvin, he told us there was a period in this earth's history when there was a molten envelope something like twenty-five miles deep round the globe which seems to have given place to the aqueous condition of our globe through condensation of vapour.

Then we have the next thing represented, viz., that "the spirit of God moved on the face of the waters." It is very remarkable we should have these two distinct words, the "deep" and the "waters." They are evidently used deliberately to indicate two conditions.

Then Professor Logan Lobley has told us there subsequently came a period when the dry land appeared. We do not know what the first continental land may have been; but the late Professor Dawson has told us about the Laurentian formation—the Laurentian upheavals and Laurentian deposits; and then we have, following the formation of land, the formation of plant life. Professor Lobley told us about the cryptogamic and the phanerogamic coming at the first appearance of continental land, and in that chapter you have the statement made that God created green things, and two classes are mentioned—herbs and the tree, "every tree in the which is the fruit of a tree yielding seed." So that the cryptogamic and phanerogamic are mentioned in that chapter. Then we have a statement of the reptiles following the Carboniferous period—creatures which, as Professor Lobley says, were as much as seventy-five feet long.

Then next you come to the creation of the mammalia and cattle, and you have exactly that same thing in the paper in our hands, following, as you see, the period of the Cretaceous strata. Then you have finally the creation of man—the last of all the works of God. "And then God rested from all His work which He had created and made"; and it does certainly appear that there is no creative action going on at the present time, but that the Almighty is "keeping His Sabbath." Whether or not that creative power may be put forward again we do not know, at any rate until, as we are told in the inspired record, "God will create a new heaven and a new earth." It seems to me that the two records fit each other as closely as hand and glove, and it seems impossible to account for the writing of this beautiful chapter, so many thousands of years ago, unless we attribute to it an inspiration which affects the very words and language in which the chapter is written.

The Rev. Canon GIRDLESTONE, M.A.—I think it is very good sometimes to survey shortly that which we are dwelling upon, the earth and its foundation, and I think the paper brings us to three good results. First, the unity of the earth; secondly, its progressiveness; and thirdly, the preparedness of the earth for man—its adjustment to man as he is, not to man as he is destined to be hereafter, because I had in my mind all the time through the reading of the paper a little sentence which shows that there is something yet coming, reserved till the end when He said, "I go to prepare a place for you." That shows that there is a long preparatory process going on now, perhaps through the relationship of our present earth, with its fellow-planets and sun, to other heavenly bodies; but there is this preparatory process going on whereby the habitation once prepared for man as he is will be adapted to man as he is to be, and there will be the same complete adjustment in the second case as in the first.

Another point which must strike everybody, I should think, as we have been through this paper, is the utility of fossils, because if all fossils had been reduced to nothingness, which would have been the case, no doubt, if all the rocks had been igneous instead of in most cases sedimentary, there would not have been a single trace of the animals and vegetation that have existed before the human period. What a serious loss that would have been!

The only other thing that strikes me is that after all I suppose we have only got some thirty-five miles down out of the eight thousand which would be requisite to carry us through the depths of the earth, and, therefore, we are only dealing with the crust of this wonderful globe on which we live. It is a good thing, sometimes, to remember that all this is the roof, as it were, that the building is beneath—and a wonderfully good roof it is, a roof that took a long time to prepare; but beneath are the phenomena touched upon in the earlier part of this paper, and I observe that the Professor said on his last page that all the later sedimentary rocks depend for their existence on the composition of the original rocks. So that there must have been in the composition of the original rocks everything that was required to produce all materials—a clear evidence of design in the formation of the earth.

After some observations by Mr. MARTIN ROUSE,

The CHAIRMAN.—I should like to ask Professor Logan Lobley about the *Dryopithecus* referred to on page 97. A great many genera are mentioned in connection with the period he there refers to. He says, "According to Gaudry, the first anthropoid ape, the *Dryopithecus*, appears"—the middle-sized monkey and the long-necked one, whether he considers the *Cœnopithecus* to be a monkey or an ape. In the middle of page 97 he speaks of "the earliest allied form to monkeys," and later on he speaks of "the first anthropoid ape," which Owen thinks is more allied to the gibbons.

Professor LOGAN LOBLEY.—I am greatly indebted to you for the kindness with which you have listened to my paper. I am much obliged to Professor Hull for his very kind supplementary remarks and also for the very interesting remarks that were subsequently made.

It was a very great pleasure to me to prepare this paper and to read it, and I am especially glad to be here to-day to meet the Institute with this subject in hand.

I did not quite understand the question you asked me, Mr. Chairman, about the *Cœnopithecus.*

The CHAIRMAN.—Whether you considered it to be more of a monkey than an ape?

Professor LOGAN LOBLEY.—More allied to the monkey. The anthropoid ape appears later. I do not know that I have any other question to reply to. I again thank you very much for your kindness.

The Meeting then terminated.

THE FOLLOWING COMMUNICATIONS WERE RECEIVED:—

From Colonel WILLIAM CAREY, C.B.:—

"I very much regret not having been able to attend Professor Lobley's lecture on 'The Preparation of the Earth's Surface for Man's Abode.' I consider the same an exceedingly good one and most interesting, but his division of time into three epochs, viz., Hypothetical, Consequential, and Historical—without any particular reference to how the same fitted in with the six days or periods of creation as given in Genesis of our Scriptures—I think was a very great pity; and although he places the appearance of man about the time of the Glacial period, not only is no possible or probable date for it noted for the ignorant in geology, but at the same time it raises the question of a pre-Adamite man allowable by the accounts given in the first and second chapters of Genesis.

"Yet for all this his consequential and historical account is clear enough to demonstrate that the order of those periods agrees with the testimony of the Books."

Mr. WILLIAM MILLER, Broughty Ferry:—

"'The Preparation of the Earth for Man's Abode.'—This is a very excellent summary of geological history prior to the advent of man, but I feel that the author does not bring out with sufficient clearness the fact that all the changes to which he refers appear to have had that advent in view as their principal object; that there was throughout the whole of their history a prophetic declaration of that object, and that man is the only being that ever existed who had sufficient intelligence to understand and appropriate for his own use the various natural productions which are now seen so beautifully to converge for his comfort and advancement in the world.

"Still further I would have liked to hear what he had to say as to the introduction of the domestic animals, the horse, ox, sheep, etc., immediately prior to the advent of man, for whose use I think they were evidently intended, to serve as his companions and servants,* but this may not have come within his subject, if he meant to confine himself strictly to 'the preparation of the earth for man's abode.'"

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* See Genesis ii, 18, 19.