

THE EARTH & MAN



J. W. DAWSON LL.D., F.R.S.

NATURE, SCIENCE, AND REVELATION.

~~~~~  
*In large crown 8vo, price 9s., cloth.*

## THE HIGHER MINISTRY OF NATURE

VIEWED IN THE LIGHT OF MODERN SCIENCE.

BY

JOHN B. LEIFCHILD, A.M.,

AUTHOR OF "OUR COAL FIELDS AND OUR COAL PITS;" "CORNWALL: ITS  
MINES AND MINERS," ETC., ETC.

~~~~~

"Mr. Leifchild is well known from his contributions to the practical departments of Physical Geography. He writes with great vigour and charm of style, and has acquired by long communion with Nature the right to speak of its higher ministry, and of the 'authentic tidings' which it brings from the mind and heart and will of God."—*British Quarterly Review*.

"This is an able and interesting book, and one which for its purpose and scope we are glad to have an opportunity of recommending."—*Globe*.

"Mr. Leifchild does not fear to confront the most advanced theories of mere Naturalism in a free and fair spirit. His book is one of sound knowledge and sober thought, and is likely to be useful at the present time."—*Illustrated London News*.

"The author takes up his position under circumstances that entitle him to a fair and impartial hearing on either side. He is known to science as a writer on geological subjects, whose contributions deserve the highest respect, while his right to be heard as a theologian is manifest in the conservative yet purely scientific spirit in which theology is treated. A timely and in many senses a rich contribution to the mental necessities of our times; it is the work of a mind comprehensive in its grasp, deep in its sympathy with nature, and strong in its love of truth. Its scope is broad, comprising on the one hand the largest questions possible to thought, and on the other the minutest details of the latest research. The philosophy of death, the question of resurrection, the certainty of immortality, the future continuity of our knowledge of God in His works, and the consequent heaven of mind, are all considered with the reverence of a Christian and the calmness of a man of science. The author seizes with exquisite aptitude the latest discourses and hypotheses of science, and by analogical reasoning marshals them in support and elucidation of the highest claims of religious thought."—*London Quarterly Review*.

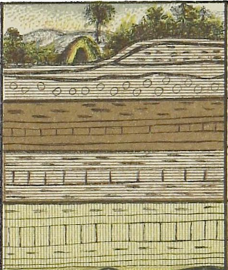
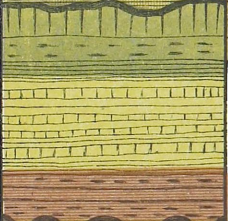
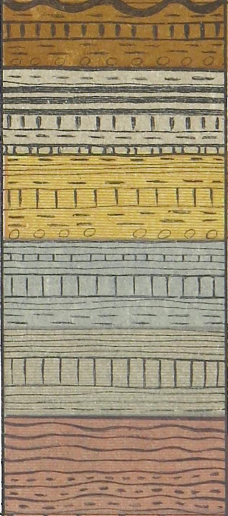

James Gelland

Port Hope, 1874.

THE STORY
OF
THE EARTH AND MAN.

*Issued in Canada by special arrangement with Messrs. Hodder & Stoughton,
the English Publishers.*

DIAGRAM OF THE EARTH'S HISTORY.

ANIMALS	ROCK FORMATIONS		PLANTS
Age of Man (Upper Strata) and Mammals	NEOZOIC Time		Modern Post-pleiocene Pliocene Miocene Eocene Age of Angio-sperms and Palms
Age of Reptiles	MESOZOIC Time		Cretaceous Jurassic Triassic Age of Cycads and Pines
Age of Amphibians and Fishes ——— Age of Mollusks, Corals and Crustaceans	PALÆOZOIC Time		Permian Carboniferous Erian, or Devonian Silurian Siluro-Cambrian Cambrian Huronian? Age of Acrogens and Gymnosperms ——— Age of Algæ
Age of Protozoa	EOZOIC Time		Laurentian Plants not determinable

THE STORY
OF
THE EARTH AND MAN.

BY
J. W. DAWSON, LL.D., F.R.S., F.G.S.,
PRINCIPAL AND VICE-CHANCELLOR OF MCGILL UNIVERSITY, MONTREAL.
AUTHOR OF "ARCHAIA," "ACADIAN GEOLOGY," ETC.

Toronto:
COPP CLARK & CO.
MDCCLXXIII.

PREFACE.

THE science of the earth as illustrated by geological research, is one of the noblest outgrowths of our modern intellectual life. Constituting the sum of all the natural sciences in their application to the history of our world, it affords a very wide and varied scope for mental activity, and deals with some of the grandest problems of space and time and of organic existence. It invites us to be present at the origin of things, and to enter into the very workshop of the Creator. It has, besides, most important and intimate connection with the industrial arts and with the material resources at the disposal of man. Its educational value, as a means of cultivating the powers of observing and reasoning, and of accustoming the mind to deal with large and intricate questions, can scarcely be overrated.

But fully to serve these high ends, the study of geology must be based on a thorough knowledge of the subjects which constitute its elementary data. It must be divested as far as possible of merely local colouring, and of the prejudices of specialists. It must be emancipated from the control of the bald metaphysical speculations so rife in our time, and

above all it must be delivered from that materialistic infidelity, which, by robbing nature of the spiritual element, and of its presiding Divinity, makes science dry, barren, and repulsive, diminishes its educational value, and even renders it less efficient for purposes of practical research.

That the want of these preliminary conditions mars much of the popular science of our day is too evident; and I confess that the wish to attempt something better, and thereby to revive the interest in geological study, to attract attention to its educational value, and to remove the misapprehensions which exist in some quarters respecting it, were principal reasons which induced me to undertake the series of papers for the *Leisure Hour*, which are reproduced, with some amendments and extension, in the present work. How far I have succeeded, I must leave to the intelligent and, I trust, indulgent reader to decide. In any case I have presented this many-sided subject in the aspect in which it appears to a geologist whose studies have led him to compare with each other the two great continental areas which are the classic ground of the science, and who retains his faith in those unseen realities of which the history of the earth itself is but one of the shadows projected on the field of time.

To geologists who may glance at the following

pages, I would say that, amidst much that is familiar, they will find here and there some facts which may be new to them, as well as some original suggestions and conclusions as to the relations of things, which though stated in familiar terms, I have not advanced without due consideration of a wide range of facts. To the general reader I have endeavoured to present the more important results of geological investigation divested of technical difficulties, yet with a careful regard to accuracy of statement, and in such a manner as to invite to the farther and more precise study of the subject in nature, and in works which enter into technical details. I have endeavoured as far as possible to mention the authors of important discoveries; but it is impossible in a work of this kind to quote authority for every statement, while the omission of much important matter relating to the topics discussed is also unavoidable. Shortcomings in these respects must be remedied by the reader himself, with the aid of systematic text-books. Those who may desire any farther explanation of the occasional allusions to the record of creation in Genesis, will find this in my previously published volume entitled "Archaia."

J. W. D.

McGILL COLLEGE, MONTREAL,
January, 1873.

CONTENTS.

	PAGE
CHAPTER I.—THE GENESIS OF THE EARTH.	
Uniformity and Progress.—Internal Heat.—Nebular Theory.—Probable Condition of the Primitive World	1
CHAPTER II.—THE Eozoic Ages.	
The Laurentian Rocks.—Their Character and Distribution.—The Conditions of their Deposition.—Their Metamorphism.—Eozoon Canadense.—Laurentian Vegetation	17
CHAPTER III.—THE PRIMORDIAL OR CAMBRIAN AGE.	
Connection of the Laurentian and Primordial.—Animals of the Primordial Seas.—Lingula, Trilobites, Oldhamia, etc.—The terms Cambrian and Silurian.—Statistics of Primordial Life	36
CHAPTER IV.—THE SILURIAN AGES.	
Geography of the Continental Plateaus.—Life of the Silurian.—Reign of Invertebrates.—Corals, Crinoids, Mollusks, Crustaceans.—The First Vertebrates.—Silurian Fishes.—Land Plants	56
CHAPTER V.—THE DEVONIAN OR ERIAN AGE.	
Physical Character of the Age.—Difference of Deposits in Marginal and Continental Areas.—Specialisation of Physical Geography.—Corals, Crustaceans, Fishes, Insects, Plants	81

CHAPTER VI.—THE CARBONIFEROUS AGE.		PAGE
Perfection of Palæozoic Life.—Carboniferous Geography.		
—Colours of Sediments.—Vegetation.—Origin of Coal.		
—Land Life.—Reptiles, Land Snails, Millipedes, etc.		
—Oceanic Life		109
CHAPTER VII.—THE PERMIAN AGE.		
Movements of the Land.—Plication of the Crust.—Chemical Conditions of Dolomite, etc.—Geographical Results of Permian Movements.—Life of the Period.		
—Summary of Palæozoic History		160
CHAPTER VIII.—THE MESOZOIC AGES.		
Characters of the Trias.—Summary of Changes in the Triassic and Cretaceous Periods.—Changes of the Continental Plateaus.—Relative Duration of the Palæozoic and Mesozoic.—Mesozoic Forests.—Land Animals.—The reign of Reptiles.—Early Mammals and Birds		188
CHAPTER IX.—THE MESOZOIC AGES—(<i>continued</i>).		
Animals of the Sea.—Great Sea Lizards, Fishes, Cephalopods, etc.—Chalk and its History.—Tabular View of the Mesozoic Ages		211
CHAPTER X.—THE NEOZOIC AGES.		
Physical Changes at the end of Mesozoic.—Subdivisions of the Neozoic.—Great Eocene Seas.—Land Animals and Plants.—Life of the Miocene.—Reign of Mammals		235
CHAPTER XI.—THE NEOZOIC AGES—(<i>continued</i>).		
Later Vegetation.—The Animals of the Pliocene Period.—Approach of the Glacial Period.—Character of the Post-pliocene or Glacial		258

CHAPTER XII.—CLOSE OF THE POST-PLIOCENE, AND
ADVENT OF MAN.

	PAGE
Connection of Geological and Human History.—The Post-glacial Period.—Its Relations to the Pre-Historic Human Period.—Elevation of Post-Pliocene Land.—Introduction of Man.—Subsidence and Re-elevation.—Calculations as to Time.—Tabular View of the Neozoic Ages	282

CHAPTER XIII.—ADVENT OF MAN—(*continued*).

Relations of Post-pliocene and Modern Animals.—Cavern Deposits.—Kent's Cave.—General Remarks	299
--	-----

CHAPTER XIV.—PRIMITIVE MAN.

Theory of Evolution as applied to Man.—Its Demands.—Its Deficiencies.—Fallacious Character of Arguments of Derivationists.—Hypothesis of Creation.—Its Demands and Advantages	316
---	-----

CHAPTER XV.—PRIMITIVE MAN—(*continued*).

Geological Conditions of Man's Introduction.—His Modern Date.—His Isolated Position.—His Higher Powers.—Pictures of Primitive Man according to Evolution and Creation.—General Conclusions	356
--	-----

LIST OF ILLUSTRATIONS.

	PAGE
IDEAL SECTIONS ILLUSTRATING THE GENESIS OF THE EARTH	8
AMERICA IN THE LAURENTIAN PERIOD	18
EOZOON CANADENSE	24
LIFE IN THE PRIMORDIAL AGE	40
ORGANIC LIMESTONE OF THE SILURIAN	63
LIFE IN THE SILURIAN	66
LIFE IN THE DEVONIAN	88
VEGETATION OF THE DEVONIAN	103
CARBONIFEROUS PLANTS	126
OLDEST LAND SNAILS	139
CARBONIFEROUS REPTILES	146
FOLDINGS OF THE CRUST IN THE PERMIAN PERIOD	162
CURVES OF ELEVATION AND DEPRESSION	179
CULMINATION OF TYPES OF PALÆOZOIC ANIMALS	183
LAND ANIMALS OF THE MESOZOIC	194
AQUATIC ANIMALS OF THE MESOZOIC	219
FORAMINIFERAL ROCK-BUILDERS	243
MIOCENE MAMMALS	253
BRITAIN IN THE POST-PLIOCENE	301

The Story of the Earth and Man.

CHAPTER I.

THE GENESIS OF THE EARTH.

THE title of this work is intended to indicate precisely its nature. It consists of rough, broad sketches of the aspects of successive stages in the earth's history, as disclosed by geology, and as they present themselves to observers at the present time. The last qualification is absolutely necessary, when dealing with a science whose goal to-day will be its starting point to-morrow, and in whose view every geological picture must have its light and shaded portions, its clear foreground and its dim distance, varying according to the lights cast on them by the progress of investigation, and according to the standpoint of the observer. In such pictures results only can be given, not the processes by which they have been obtained; and with all possible gradations of light and distance, it may be that the artist will bring into too distinct outline facts still only dimly perceived, or will give too little prominence to

others which should appear in bold relief. He must in this judge for himself; and if the writer's impressions do not precisely correspond with those of others, he trusts that they will allow something for difference of vision and point of view.

The difficulty above referred to perhaps rises to its maximum in the present chapter. For how can any one paint chaos, or give form and filling to the formless void? Perhaps no word-picture of this period of the first phase of mundane history can ever equal the two negative touches of the inspired penman—"without form and void"—a world destitute of all its present order, and destitute of all that gives it life and animation. This it was, and not a complete and finished earth, that sprang at first from its Creator's hand; and we must inquire in this first chapter what information science gives as to any such condition of the earth.

In the first place, the geological history of the earth plainly intimates a beginning, by utterly negating the idea that "all things continue as they were from the creation of the world." It traces back to their origin not only the animals and plants which at present live, but also their predecessors, through successive dynasties emerging in long procession from the depths of a primitive antiquity. Not only so; it assigns to their relative ages all the rocks of the earth's crust, and all the plains and mountains built up of them. Thus, as we go back in geological time, we leave behind us, one by one, all the things with which we

are familiar, and the inevitable conclusion gains on us that we must be approaching a beginning, though this may be veiled from us in clouds and thick darkness. How is it, then, that there are "Uniformitarians" in geology, and that it has been said that our science shows no traces of a beginning, no indications of an end? The question deserves consideration; but the answer is not difficult. In all the lapse of geological time there has been an absolute uniformity of natural law. The same grand machinery of force and matter has been in use throughout all the ages, working out the great plan. Yet the plan has been progressive and advancing, nevertheless. The uniformity has been in the methods, the results have presented a wondrous diversity and development. Again, geology, in its oldest periods, fails to reach the beginning of things. It shows us how course after course of the building has been laid, and how it has grown to completeness, but it contains as yet no record of the laying of the foundation-stones, still less of the quarry whence they were dug. Still the constant progress which we have seen points to a beginning which we have not seen; and the very uniformity of the process by which the edifice has been erected, implies a time when it had not been begun, and when its stones were still reposing in their native quarry.

What, then, is the oldest condition of the earth actually shown to us by geology,—that which prevailed in the Eozoic or Laurentian period, when the oldest rocks known, those constituting the foundation-

stones of our present continents, were formed and laid in their places? With regard to physical conditions, it was a time when our existing continents were yet in the bosom of the waters, when the ocean was almost universal, yet when sediments were being deposited in it as at present, while there were also volcanic foci, vomiting forth molten matter from the earth's hidden interior. Then, as now, the great physical agencies of water and fire were contending with one another for the mastery, doing and undoing, building up and breaking down. But is this all? Has the earth no earlier history? That it must have had, we may infer from many indications; but as to the nature of these earlier states, we can learn from conjecture and inference merely, and must have recourse to other witnesses than those rocky monuments which are the sure guides of the geologist.

One fact bearing on these questions which has long excited attention, is the observed increase in temperature in descending into deep mines, and in the water of deep artesian wells—an increase which may be stated in round numbers at one degree of heat of the centigrade thermometer for every 100 feet of depth from the surface. These observations apply of course to a very inconsiderable depth, and we have no certainty that this rate continues for any great distance towards the centre of the earth. If, however, we regard it as indicating the actual law of increase of temperature, it would result that the whole crust of the earth is a mere shell covering a molten mass

of rocky matter. Thus a very slight step of imagination would carry us back to a time when this slender crust had not yet formed, and the earth rolled through space an incandescent globe, with all its water and other vaporisable matters in a gaseous state. Astronomical calculation has, however, shown that the earth, in its relation to the other heavenly bodies, obeys the laws of a rigid ball, and not of a fluid globe. Hence it has been inferred that its actual crust must be very thick, perhaps not less than 2,500 miles, and that its fluid portion must therefore be of smaller dimensions than has been inferred from the observed increase of temperature. Further, it seems to have been rendered probable, from the density of rocky matter in the solid and liquid states, that a molten globe would solidify at the centre as well as at the surface, and consequently that the earth must not only have a solid crust of great thickness, but also a solid nucleus, and that any liquid portions must be of the nature of a sheet or of detached masses intervening between these. On the other hand, it has recently been maintained that the calculations which are supposed to have established the great thickness of the crust, on the ground that the earth does not change its form in obedience to the attraction of the sun and moon, are based on a misconception, and that a molten globe with a thin crust would attain to such a state of equilibrium in this respect as not to be distinguishable from a solid planet. This view has been maintained by the French

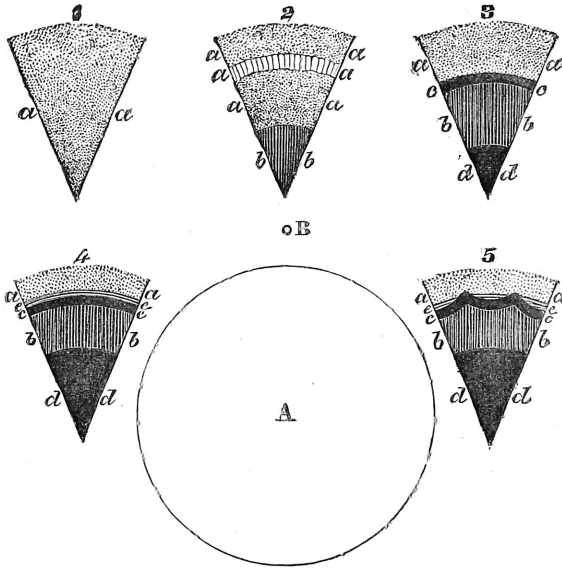
physicist, Delaunay, and for some time it made geologists suppose that, after all, the earth's crust may be very thin. Sir William Thomson, however, and Archdeacon Pratt, have ably maintained the previous opinion, based on Hopkins' calculations; and it is now believed that we may rest upon this as representing the most probable condition of the interior of the earth at present. Another fact bearing on this point is the form of the earth, which is now actually a spheroid of rotation; that is, of such a shape as would result from the action of gravity and centrifugal force in the motion of a huge liquid drop rotating in the manner in which the earth rotates. Of course it may be said that the earth may have been made in that shape to fit it for its rotation; but science prefers to suppose that the form is the result of the forces acting on it. This consideration would of course corroborate the deductions from that just mentioned. Again, if we examine a map showing the distribution of volcanoes upon the earth, and trace these along the volcanic belt of Western America and Eastern Asia, and in the Pacific Islands, and in the isolated volcanic regions in other parts of the world; and if we add to these the multitude of volcanoes now extinct, we shall be convinced that the sources of internal heat, of which these are the vents, must be present almost everywhere under the earth's crust. Lastly, if we consider the elevations and depressions which large portions of the crust of the earth have undergone in geological time, and the actual crump-

ling and folding of the crust visible in great mountain chains, we arrive at a similar conclusion, and also become convinced that the crust has been not too thick to admit of extensive fractures, flexures, and foldings. There are, however, it must be admitted, theories of volcanic action, strongly supported by the chemical nature of the materials ejected by modern volcanoes, which would refer all their phenomena to the softening, under the continued influence of heat and water, of materials within the crust of the earth rather than under it.* Still, the phenomena of volcanic action, and of elevation and subsidence, would, under any explanation, suppose intense heat, and therefore probably an original incandescent condition.

La Place long ago based a theory of the originally gaseous condition of the solar system on the relation of the planets to each other, and to the sun, on their planes of revolution, the direction of their revolution, and that of their satellites. On these grounds he inferred that the solar system had been formed out of a nebulous mass by the mutual attraction of its parts. This view was further strengthened by the discovery of nebulæ, which it might be supposed were undergoing the same processes by which the solar system was produced. This nebular theory, as it was called, was long very popular. It was subsequently supposed to be damaged by the fact that some of the nebulæ which had been regarded as systems in progress of formation were found by im-

* Dr. T. Sterry Hunt, in *Silliman's Journal*, 1870.

proved telescopes to be really clusters of stars, and it was inferred that the others might be of like character. The spectroscope has, however, more recently shown that some nebulæ are actually gaseous; and it has even been attempted to demonstrate that



Figs. 1 to 5. Ideal sections illustrating the Genesis of the Earth.

Fig. 1. A vaporous world.

Fig. 2. A world with a central fluid nucleus (b) and a photosphere (a).

Fig. 3. The photosphere darkened, and a solid crust (c) and solid nucleus (d) formed.

Fig. 4. Water (e) deposited on the crust, forming a universal ocean.

Fig. 5. The crust crumpled by shrinkage, land elevated, and the water occupying the intervening depressions.

The figures are all of uniform size; but the circle (A) shows the diameter of the globe when in the state of fig. 1, and that marked (B) its diameter when in the state of fig. 5. In all the figures (a) represents vapour or air; (b) liquid rock; (c) solid rock as a crust; (d) solid nucleus; (e) water.

they are probably undergoing change fitting them to become systems. This has served to revive the nebular hypothesis, which has been further strengthened by the known fact that the sun is still an incandescent globe surrounded by an immense luminous envelope of vapours rising from its nucleus and condensing at its surface. On the other hand, while the sun may be supposed, from its great magnitude, to remain intensely heated, and while it will not be appreciably less powerful for myriads of years, the moon seems to be a body which has had time to complete the whole history of geological change, and to become a dry, dead, and withered world, a type of what our earth would in process of time actually become.

Such considerations lead to the conclusion that the former watery condition of our planet was not its first state, and that we must trace it back to a previous reign of fire. The reasons which can be adduced in support of this are no doubt somewhat vague, and may in their details be variously interpreted; but at present we have no other interpretation to give of that chaos, formless and void, that state in which "nor aught nor nought existed," which the sacred writings and the traditions and poetry of ancient nations concur with modern science in indicating as the primitive state of the earth.

Let our first picture, then, be that of a vaporous mass, representing our now solid planet spread out over a space nearly two thousand times greater in

diameter than that which it now occupies, and whirling in its annual round about the still vaporous centre of our system, in which at an earlier period the earth had been but an exterior layer, or ring of vapour. The atoms that now constitute the most solid rocks are in this state as tenuous as air, kept apart by the expansive force of heat, which prevents not only their mechanical union, but also their chemical combination. But within the mass, slowly and silently, the force of gravitation is compressing the particles in its giant hand, and gathering the denser toward the centre, while heat is given forth on all sides from the condensing mass into the voids of space without. Little by little the denser and less volatile matters collect in the centre as a fluid molten globe, the nucleus of the future planet; and in this nucleus the elements, obeying their chemical affinities hitherto latent, are arranging themselves in compounds which are to constitute the future rocks. At the same time, in the exterior of the vaporous envelope, matters cooled by radiation into the space without, are combining with each other, and are being precipitated in earthy rain or snow into the seething mass within, where they are either again vaporised and sent to the surface or absorbed in the increasing nucleus. As this process advances, a new brilliancy is given to the faint shining of the nebulous matter by the incandescence of these solid particles in the upper layers of its atmosphere, a condition which at this moment, on a greater scale, is that of the sun; in the case of the earth, so much smaller in volume,

and farther from the centre of the system, it came on earlier, and has long since passed away. This was the glorious starlike condition of our globe: in a physical point of view, its most perfect and beautiful state, when, if there were astronomers with telescopes in the stars, they might have seen our now dull earth flash forth—a brilliant white star secondary to the sun.

But in process of time this passes away. All the more solid and less volatile substances are condensed and precipitated; and now the atmosphere, still vast in bulk, and dark and misty in texture, contains only the water, chlorine, carbonic acid, sulphuric acid, and other more volatile substances; and as these gather in dense clouds at the outer surface, and pour in fierce corrosive rains upon the heated nucleus, combining with its materials, or flashing again into vapour, darkness dense and gross settles upon the vaporous deep, and continues for long ages, until the atmosphere is finally cleared of its acid vapours and its superfluous waters.* In the meantime, radiation, and the heat abstracted from the liquid nucleus by the showers of condensing material from the atmosphere, have so far cooled its surface that a crust of slag or cinder forms upon it. Broken again and again by the heavings of the ocean of fire, it at length sets permanently, and receives upon its bare and blistered surface the ever-increasing aqueous and acid rain thrown down

* Hunt, "Chemistry of the Primeval Earth," *Silliman's Journal*, 1858.

from the atmosphere, at first sending it all hissing and steaming back, but at length allowing it to remain a universal boiling ocean. Then began the reign of the waters, and the dominion of fire was confined to the abysses within the solid crust. Under the primeval ocean were formed the first stratified rocks, from the substances precipitated from its waters, which must have been loaded with solid matter. We must not imagine this primeval ocean like our own blue sea, clear and transparent, but filled with earthy and saline matters, thick and turbid, until these were permitted to settle to the bottom and form the first sediments. The several changes above referred to are represented in diagrammatic form in figs. 1 to 4.

In the meantime all is not at rest in the interior of the new-formed earth. Under the crust vast oceans of molten rock may still remain, but a solid interior nucleus is being crystallised in the centre, and the whole interior globe is gradually shrinking. At length this process advances so far that the exterior crust, like a sheet of ice from below which the water has subsided, is left unsupported; and with terrible earthquake-throes it sinks downward, wrinkling up into huge folds, between which are vast sunken areas into which the waters subside, while from the intervening ridges the earth's pent-up fires belch forth ashes and molten rocks. (Fig. 5.) So arose the first dry land :—

“The mountains huge appear
Emergent, and their broad bare backs upheave

Into the clouds, their tops ascend the sky,
So high as heaved the tumid hills, so low
Down sunk a hollow bottom, broad and deep,
Capacious bed of waters."

The cloud was its garment, it was swathed in thick darkness, and presented but a rugged pile of rocky precipices; yet well might the "morning stars sing together, and all the sons of God shout with joy," when its foundations were settled and its cornerstone laid, for then were inaugurated the changes which were to lead to the introduction of life on the earth, and to all the future development of the continents.

Physical geographers have taught us that the great continents, whether we regard their coasts or their mountain chains, are built up on lines which run north-east and south-west, and north-west and south-east; and it is also observed that these lines are great circles of the earth tangent to the polar circle. Further, we find, as a result of geological investigation, that these lines determined the deposition and the elevation of the oldest rocks known to us. Hence it is fair to infer that these were the original directions of the first lines of fracture and upheaval. Whether these lines were originally drawn by the influence of the seasons on the cooling globe, or by the currents of its molten interior, or of the superficial ocean, they bespeak a most uniform and equable texture for the crust, and a definite law of fracture and upheaval; and they have modified all the subse-

quent action of the ocean as a depositor of sediment, and of the internal heat as a cause of alteration and movement of rocks. Against these earliest belts of land the ocean first chafed and foamed. Along their margins marine denudation first commenced, and the oceanic currents first deposited banks of sediment; and along these first lines have the volcanic orifices of all periods been most plentiful, and elevatory movements most powerfully felt.

We must not suppose that the changes thus shortly sketched were rapid and convulsive. They must have required periods of enormous duration, all of which had elapsed before the beginning of geological time, properly so called. From Sir William Thomson's calculations, it would appear that the time which has elapsed from the first formation of a solid crust on the earth to the modern period may have been from seventy to one hundred millions of years, and the whole time from the vaporous condition of the solar system to the present, must of course have been still greater than even this enormous series of ages. Such a lapse of time is truly almost inconceivable, but it is only a few days to Him with whom one day is as a thousand years, and a thousand years as one day. How many and strange pictures does this series of processes call up! First, the uniform vaporous nebula. Then the formation of a liquid nucleus, and a brilliant photosphere without. Then the congealing of a solid crust under dark atmospheric vapours, and the raining down of acid and watery showers. Then

the universal ocean, its waves rolling unobstructed around the globe, and its currents following without hindrance the leading of heat and of the earth's rotation. Then the rupture of the crust and the emergence of the nuclei of continents.

Some persons seem to think that by these long processes of creative work we exclude the Creator, and would reduce the universe into a mere fortuitous concourse of atoms. To put it in more modern phrase, "given a quantity of detached fragments cast into space, then mutual gravitation and the collision of the fragments would give us the spangled heavens." But we have still to ask the old question, "Whence the atoms?" and we have to ask it with all the added weight of our modern chemistry, so marvellous in its revelations of the original differences of matter and their varied powers of combination. We have to ask, What is gravitation itself, unless a mode of action of Almighty power? We have to ask for the origin of of thousands of correlations, binding together the past and the future in that orderly chain of causes and effects which constitutes the plan of the creation. If it pleased God to create in the beginning an earth "formless and void," and to elaborate from this all that has since existed, who are we, to say that the plan was not the best? Nor would it detract from our view of the creative wisdom and power if we were to hold that in ages to come the sun may experience the same change that has befallen the earth, and may become "black as sackcloth of hair," preparatory,

perhaps, to changes which may make him also the abode of life ; or if the earth, cooling still further, should, like our satellite the moon, absorb all its waters and gases into its bosom, and become bare, dry, and parched, until there shall be "no more sea," how do we know but that then there shall be no more need of the sun, because a better light may be provided? Or that there may not be a new baptism of fire in store for the earth, whereby, being melted with fervent heat, it may renew its youth in the fresh and heavenly loveliness of a new heaven and a new earth, free from all the evils and imperfections of the present? God is not slack in these things, as some men count slackness ; but His ways are not like our ways. He has eternity wherein to do His work, and takes His own time for each of His operations. The Divine wisdom, personified by a sacred writer, may well in this exalt his own office :—

"Jehovah possessed me in the beginning of His way,
Before His work of old.
I was set up from everlasting,
From the beginning, or ever the earth was.
When there were no deeps, I was brought forth ;
When there were no fountains abounding in water.
Before the mountains were settled,
Before the hills, was I brought forth :
While as yet He had not made the earth,
Nor the plains, nor the higher part of the habitable world,
When He gave the sea His decree,
That her waters should not pass His limits ;
When He determined the foundations of the earth."

CHAPTER II.

THE Eozoic Ages.

THE dominion of heat has passed away; the excess of water has been precipitated from the atmosphere, and now covers the earth as a universal ocean. The crust has folded itself into long ridges, the bed of the waters has subsided into its place, and the sea for the first time begins to rave against the shores of the newly elevated land, while the rain, washing the bare surfaces of rocky ridges, carries its contribution of the slowly wasting rocks back into the waters whence they were raised, forming, with the material worn from the crust by the surf, the first oceanic sediments. Do we know any of these earliest aqueous beds, or are they all hidden from view beneath newer deposits, or have they been themselves worn away and destroyed by denuding agencies? Whether we know the earliest formed sediments is, and may always remain, uncertain; but we do know certain very ancient rocks which may be at least their immediate successors.

Deepest and oldest of all the rocks we are acquainted with in the crust of the earth, are certain beds much altered and metamorphosed, baked by the joint action of heat and heated moisture—rocks once called Azoic, as containing no traces of life,

but for which I have elsewhere proposed the name "Eozoic," or those that afford the traces of the earliest known living beings. These rocks are the Laurentian Series of Sir William Logan, so named from the Laurentide hills, north of the River St. Lawrence, which are composed of these ancient beds, and where they are more largely exposed than in any other region. It may seem at first sight strange that any of these ancient rocks should be found at the surface of the earth; but this is a

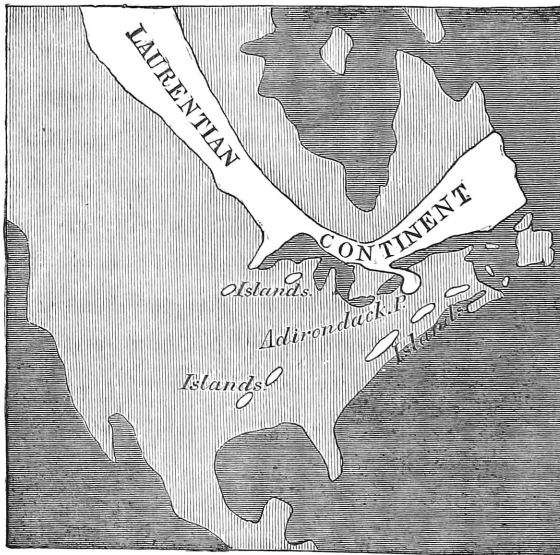


Fig. 6. The Laurentian nucleus of the American continent.

necessary result of the mode of formation of the continents. The oldest rocks, thrown up in places into high ridges, have either not been again brought

under the waters, or have lost by denudation the sediments once resting on them; and being of a hard and resisting nature, still remain, and often rise into hills of considerable elevation, showing as it were portions of the skeleton of the earth protruding through its superficial covering. Such rocks stretch along the north side of the St. Lawrence river from Labrador to Lake Superior, and thence northwardly to an unknown distance, constituting a wild and rugged district often rising into hills 4000 feet high, and in the deep gorge of the Saguenay forming cliffs 1,500 feet in sheer height from the water's edge. South of this great ridge, the isolated mass of the Adirondack Mountains rises to the height of 6,000 feet, rivalling the newer, though still very ancient, chain of the White Mountains. Along the eastern coast of North America, a lower ridge of Laurentian rock, only appearing here and there from under the overlying sediments, is seen in Newfoundland, in New Brunswick, possibly in Nova Scotia, and perhaps farther south in Massachusetts, and as far as Maryland. In the old world, rocks of this age do not, so far as known, appear so extensively. They have been recognised in Norway and Sweden, in the Hebrides, and in Bavaria, and may, no doubt, be yet discerned in other localities. Still, the grandest and most instructive development of these rocks is in North America; and it is there that we may best investigate their nature, and endeavour to restore the

conditions in which they were deposited. It has been already stated that the oldest wrinkles of the crust of the globe take the direction of great circles of the earth tangent to the polar circle, forming north-east and south-west, and north-west and south-east lines. To such lines are the great exposures of Laurentian rock conformed, as may be well seen from the map of North America (fig. 6), taken from Dana, with some additions. The great angular Laurentian belt is evidently the nucleus of the continent, and consists of two broad bands or ridges meeting in the region of the great lakes. The remaining exposures are parallel to these, and appear to indicate a subordinate coast-line of comparatively little elevation. It is known that these Laurentian exposures constitute the oldest part of the continent, a part which was land before any of the rocks of the shaded portion of the map were deposited in the bed of the ocean—all this shaded portion being composed of rocks of various geological ages resting on the older Laurentian. It is further to be observed that the beds occurring in the Laurentian bands are crumpled and folded in a most remarkable manner, and that these folds were impressed upon them before the deposition of the rocks next in geological age.

What then are these oldest rocks deposited by the sea—the firstborn of the reign of the waters? They are very different in their external aspect from the silt and mud, the sand and gravel, and the shell and coral rocks of the modern sea, or of the more

recent geological formations. Yet the difference is one in condition rather than composition. The members of this ancient aristocracy of the rocks are made of the same clay with their fellows, but have been subjected to a refining and crystallizing process which has greatly changed their condition. They have been, as geologists say, metamorphosed; and are to ordinary rocks what a china vase is to the lump of clay from which it has been made. Deeply buried in the earth under newer sediments, they have been baked, until sandstones, gravels, and clays came out bright and crystalline, as gneiss, mica-schist, hornblende-schist, and quartzite—all hard crystalline rocks showing at first sight no resemblance to their original material, except in the regularly stratified or bedded arrangement which serves to distinguish them from igneous or volcanic rocks. In like manner certain finer, calcareous sediments have been changed into Labrador feldspar, sometimes gay with a beautiful play of colour, and what were once common limestones appear as crystalline marble. If the evidence of such metamorphoses is asked for, this is twofold. In the first place, these rocks are similar in structure to more modern beds which have been partially metamorphosed, and in which the transition from the unaltered to the altered state can be observed. Secondly, there are limited areas in the Laurentian itself, in which the metamorphism has been so imperfect as to permit traces of the original character of the rocks

to remain. It seems also quite certain, and this is a most important point for our sketch, that the Laurentian ocean was not universal, but that there were already elevated portions of the crust capable of yielding sediment to the sea.

In North America these Laurentian rocks attain to an enormous thickness. This has been estimated by Sir W. E. Logan at 30,000 feet, so that the beds would, if piled on each other horizontally, be as high as the highest mountains on earth. They appear to consist of two great series, the Lower and Upper Laurentian. Even if we suppose that in the earlier stages of the world's history erosion and deposition were somewhat more rapid than at present, the formation of such deposits, probably more widely spread than any that succeeded them, must have required an enormous length of time.

Geologists long looked in vain for evidences of life in the Laurentian period; but just as astronomers have suspected the existence of unknown planets from the perturbations due to their attraction, geologists have guessed that there must have been some living things on earth even at this early time. Dana and Sterry Hunt especially have committed themselves to such speculations. The reasons for this belief may be stated thus: (1.) In later formations limestone is usually an organic rock, produced by the accumulation of shells, corals, and similar calcareous organisms in the sea, and there are enormous limestones in the Laurentian, constituting regular beds.

(2.) In later formations coaly matter is an organic substance, derived from vegetables, and there are large quantities of Laurentian carbon in the form of graphite. (3.) In later formations deposits of iron ores are almost always connected with the deoxidising influence of organic matters as an efficient cause of their accumulation, and the Laurentian contains immense deposits of iron ore, occurring in layers in the manner of later deposits of these minerals. (4.) The limestone, carbon, and iron of the Laurentian exist in association with the other beds in the same manner as in the later formations in which they are known to be organic.

In addition to this inferential evidence, however, one well-marked animal fossil has at length been found in the Laurentian of Canada, *Eozoon Canadense*, (fig. 7), a gigantic representative of one of the lowest forms of animal life, which the writer had the honour of naming and describing in 1865—its name of “Dawn-animal” having reference to its great antiquity and possible connection with the dawn of life on our planet. In the modern seas, among the multitude of low forms of life with which they swarm, occur some in which the animal matter is a mere jelly, almost without distinct parts or organs, yet unquestionably endowed with life of an animal character. Some of these creatures, the Foraminifera, have the power of secreting at the surface of their bodies a calcareous shell, often divided into numerous chambers, communicating with each other, and with the

water without, by pores or orifices through which the animal can extend soft and delicate prolongations of its gelatinous body, which, when stretched out into the water, serve for arms and legs. In modern times

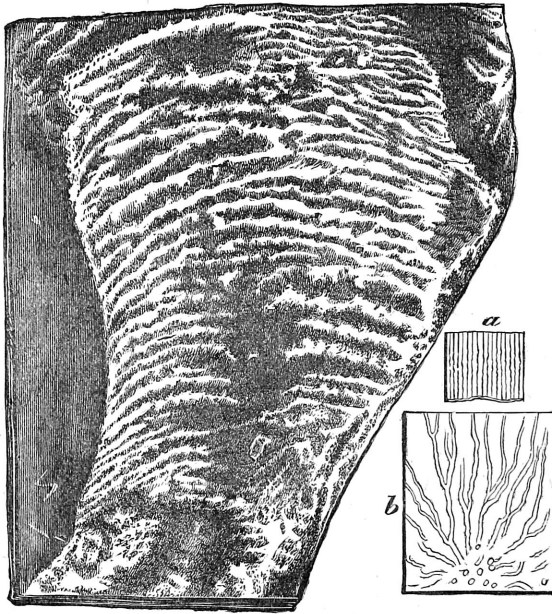


Fig. 7. *Eozoon Canadense*. Dawson.

The oldest known animal. Portion of skeleton, two-thirds natural size. (a) Tubulated cell-wall, magnified. (b) Portion of canal system, magnified.

these creatures, though extremely abundant in the ocean, are usually small, often microscopic; but in a fossil state there are others of somewhat larger size, though few equalling the Eozoon, which seems to have been a sessile creature, resting on the bottom of

the sea, and covering its gelatinous body with a thin crust of carbonate of lime or limestone, adding to this, as it grew in size, crust after crust, attached to each other by numerous partitions, and perforated with pores for the emission of gelatinous filaments. This continued growth of gelatinous animal matter and carbonate of lime went on from age to age, accumulating great beds of limestone, in some of which the entire form and most minute structures of the creature are preserved, while in other cases the organisms have been broken up; and the limestones are a mere congeries of their fragments. It is a remarkable instance of the permanence of fossils, that in these ancient organisms the minutest pores through which the semi-fluid matter of these humble animals passed, have been preserved in the most delicate perfection. The existence of such creatures supposes that of other organisms, probably microscopic plants, on which they could feed. No traces of these have been observed, though the great quantity of carbon in the beds probably implies the existence of larger seaweeds. No other form of animal has yet been distinctly recognized in the Laurentian limestones, but there are fragments of calcareous matter which may have belonged to organisms distinct from Eozoon. Of life on the Laurentian land we know nothing, unless the great beds of iron ore already referred to may be taken as a proof of land vegetation.*

* It is proper to state here that some geologists and naturalists still doubt the organic nature of Eozoon. Their objections,

To an observer in the Laurentian period, the earth would have presented an almost boundless ocean, its waters, perhaps, still warmed with the internal heat, and sending up copious exhalations to be condensed in thick clouds and precipitated in rain. Here and there might be seen chains of rocky islands, many of them volcanic, or ranges of bleak hills, perhaps clothed with vegetation the forms of which are unknown to us. In the bottom of the sea, while sand and mud and gravel were being deposited in successive layers in some portions of the ocean floor, in others great reefs of Eozoon were growing up in the manner of reefs of coral. If we can imagine the modern Pacific, with its volcanic islands and reefs of coral, to be deprived of all other forms of life, we should have a somewhat accurate picture of the Eozoic time as it appears to us now. I say as it appears to us now; for we do not know what new discoveries remain to be made. More especially the immense deposits of carbon and iron in the Laurentian would seem to bespeak a profusion of plant life in the sea or on the land, or both, second to that of no other period that succeeded, except that of the great coal formation. Perhaps no remnant of this primitive vegetation exists retaining its form or structure; but we may hope for better things, and

however, so far as stated publicly, have been shown to depend on misapprehension as to the structures observed and their state of preservation; and specimens recently found in comparatively unaltered rocks have indicated the true character of those more altered by metamorphism.

cherish the expectation that some fortunate discovery may still reveal to us the forms of the vegetation of the Laurentian time.

It is remarkable that the humbly organized living things which built up the Laurentian limestones have continued to exist unchanged, save in dimensions, up to modern times; and here and there throughout the geological series we find beds of Foraminiferous limestone, similar, except in the species of Foraminifera composing them, to that of the Laurentian. It is true that other kinds of creatures, the coral animals more particularly, have been introduced, and have proved equally efficient builders of limestones; but in the deeper parts of the sea the Foraminifera continue to assert their pre-eminence in this respect, and the dredge reveals in the depths of our modern oceans beds of calcareous matter which may be regarded as identical in origin with the limestones formed in the period which is to us the dawn of organic life.

Many inquiries suggest themselves to the zoologist in connection with the life of the Laurentian period. Was Eozoon the first creature in which the wondrous forces of animal life were manifested, when, in obedience to the Divine fiat, the waters first "swarmed with swarms," as the terse and expressive language of the Mosaic record phrases it? If so, in contemplating this organism we are in the presence of one of the greatest of natural wonders—brought nearer than in any other case to the actual workshop of the Almighty Maker. Still we cannot affirm that other

creatures even more humble may not have preceded Eozoon, since such humble organisms are known in the present world. Attempts have often been made, and very recently have been renewed with much affirmation of success, to prove that such low forms of life may originate spontaneously from their materials in the waters; but so far these attempts merely prove that the invisible germs of the lower animals and plants exist everywhere, and that they have marvellous powers of resisting extreme heat and other injurious influences. We need not, therefore, be surprised if even lower forms than Eozoon may have preceded that creature, or if some of these may be found, like the organisms said to live in modern boiling springs, to have had the power of existing even at a time when the ocean may have been almost in a state of ebullition. Another problem is that of means of subsistence for the Eozoic Foraminifera. A similar problem exists in the case of the modern ocean, in whose depths live multitudes of creatures, where, so far as we know, vegetable matter, ordinarily the basis of life, cannot exist in a living condition. It is probable, however, from the researches of Dr. Wyville Thompson, that this is to be accounted for by the abundance of life at the surface and in the shallower parts of the sea, and by the consequent diffusion through the water of organic matter in an extremely tenuous state, but yet sufficient to nourish these creatures. The same may have been the case in the Eozoic sea, where, judging from the vast amount of

residual carbon, there must have been abundance of organic matter, either growing at the bottom, or falling upon it from the surface; and as the Eozoon limestones are usually free from such material, we may assume that the animal life in them was sufficient to consume the vegetable pabulum. On the other hand, as detached specimens of Eozoon occur in graphitic limestones, we suppose that in some cases the vegetable matter was in excess of the animal, and this may have been either because of its too great exuberance, or because the water was locally too shallow to permit Eozoon and similar creatures to flourish. These details we must for the present fill up conjecturally; but the progress of discovery may give us further light as to the precise conditions of the beginning of life in the "great and wide sea wherein are moving things innumerable," and which is as much a wonder now as in the days of the author of the "Hymn of Creation,"* in regard to the life that swarms in all its breadth and depth, the vast variety of that life, and its low and simple types, of which we can affirm little else than that they move.

The enormous accumulations of sediment on the still thin crust of the earth in the Laurentian period—accumulations probably arranged in lines parallel to the directions of disturbance already indicated—weighed down the surface, and caused great masses of the sediment to come within the influence of the heated interior nucleus. Thus, extensive meta-

* Psalm civ.

morphism took place, and at length the tension becoming too great to be any longer maintained, a second great collapse occurred, crumpling and disturbing the crust, and throwing up vast masses of the Laurentian itself, probably into lofty mountains—many of which still remain of considerable height, though they have been subjected to erosion throughout all the extent of subsequent geological time.

The Eozoic age, whose history we have thus shortly sketched, is fertile in material of thought for the geologist and the naturalist. Until the labours of Murchison, Sedgwick, Hall, and Barrande had developed the vast thickness and organic richness of the Silurian and Cambrian rocks, no geologist had any idea of the extent to which life had reached backward in time. But when this new and primitive world of Siluria was unveiled, men felt assured that they had now at last reached to the beginnings of life. The argument on this side of the question was thus put by one of the most thoughtful of English geologists, Professor Phillips: "It is ascertained that in passing downwards through the lower Palæozoic strata, the forms of life grow fewer and fewer, until in the lowest Cambrian rocks they vanish entirely. In the thick series of these strata in the Longmynd, hardly any traces of life occur, yet these strata are of such a kind as might be expected to yield them. . . . The materials are fine-grained or arenaceous, with or without mica, in laminæ or beds quite distinct, and of various thicknesses, by no means unlikely to retain

impressions of a delicate nature, such as those left by graptolites, or mollusks, or annulose crawlers. Indeed, one or two such traces are supposed to have been recognised, so that the almost total absence of the traces of life in this enormous series is best understood by the supposition that in these parts of the sea little or no life existed. But the same remark of the excessive rarity of life in the lower deposits is made in North America, in Norway, and in Bohemia, countries well searched for this very purpose, so that all our observations lead to the conviction that the lowest of all the strata are quite deficient of organic remains. The absence is general—it appears due to a general cause. Is it not probable that during these very early periods the ocean and its sediments were nearly devoid of plants and animals, and in the earliest time of all, which is represented by sediments, quite deprived of such?" These words were written ten years ago, and about the same time were published in America those anticipations of the probability of life in the Laurentian already referred to, and Lyell was protesting against the name Primordial, on the ground that it implied that we had reached the beginning of life, when this was not proved. Yet there were elements of truth in both views. It is true now, as then, that the Primordial seems to be a morning hour of life, having, as we shall see in our next paper, unmistakable signs about it of that approach to the beginning to which Phillips refers. It is also true that it is not so early a morning hour as one who has

not risen with the dawn might suppose, since with its apparently small beginnings of life it is almost as far removed from the Eozoon reefs of the early Laurentian on the one hand, as it is from the modern period on the other. The dawn of life seems to have been a very slow and protracted process, and it may have required as long a time between the first appearance of Eozoon and the first of those primordial Trilobites which the next period will introduce to our notice, as between these and the advent of Adam. Perhaps no lesson is more instructive than this as to the length of the working days of the Almighty.

Another lesson lies ready for us in these same facts. Theoretically, plants should have preceded animals; and this also is the assertion of the first chapter of Genesis; but the oldest fossil certainly known to us is an animal. What if there were still earlier plants, whose remains are still to be discovered? For my own part, I can see no reason to despair of the discovery of an *Eophytic* period preceding the Eozoic; perhaps preceding it through ages of duration to us almost immeasurable, though still within the possible time of the existence of the crust of the earth. It is even possible that in a warm and humid condition of the atmosphere, before it had been caused "to rain upon the earth," and when dense "mists ascended from the earth and watered the whole surface of the ground,"* vegetation may have attained to a

* Genesis ii. 5. For a description of this Eophytic period of Genesis, see the Author's "Archaia," pp. 160 *et seq.*

profusion and grandeur unequalled in the periods whose flora is known to us.

But while Eozoon thus preaches of progress and of development, it has a tale to tell of unity and sameness. Just as Eozoon lived in the Laurentian sea, and was preserved for us by the infiltration of its canals with siliceous mineral matters, so its successors and representatives have gone on through all the ages accumulating limestone in the sea bottom. To-day they are as active as they were then, and are being fossilised in the same way. The English chalk and the chalky modern mud of the Atlantic sea-bed, are precisely similar in origin to the Eozoic limestones. There is also a strange parallelism in the fact that in the modern seas Foraminifera can live under conditions of deprivation of light and vital air, and of enormous pressure, under which few organisms of greater complexity could exist, and that in like manner Eozoon could live in seas which were perhaps as yet unfit for most other forms of life.

It has been attempted to press the Eozoic Foraminifers into the service of those theories of evolution which would deduce the animals of one geological period by descent with modification from those of another; but it must be confessed that Eozoon proves somewhat intractable in this connection. In the first place, the creature is the grandest of his class, both in form and structure; and if, on the hypothesis of derivation, it has required the whole lapse of geological time to disintegrate Eozoon into Orbulina,

Globigerina, and other comparatively simple Foraminifers of the modern seas, it may have taken as long, probably much longer, to develop Eozoon from such simple forms in antecedent periods. Time fails for such a process. Again, the deep sea has been the abode of Foraminifers from the first. In this deep sea they have continued to live without improvement, and with little material change. How little likely is it that in less congenial abodes they could have improved into higher grades of being; especially since we know that the result in actual fact of any such struggle for existence is merely the production of depauperated Foraminifers? Further, there is no link of connection known to us between Eozoon and any of the animals of the succeeding Primordial, which are nearly all essentially new types, vastly more different from Eozoon than it is from many modern creatures. Any such connection is altogether imaginary and unsupported by proof. The laws of creation actually illustrated by this primeval animal are only these: First, that there has been a progress in creation from few, low, and generalised types of life to more numerous, higher, and more specialised types; and secondly, that every type, low or high, was introduced at first in its best and highest form, and was, as a type, subject to degeneracy, and to partial or total replacement by higher types subsequently introduced. I do not mean that we could learn all this from Eozoon alone; but that, rightly considered, it illustrates these laws, which we gather from the

subsequent progress of the creative work. As to the mystery of the origin of living beings from dead matter, or any changes which they may have undergone after their creation, it is absolutely silent.

CHAPTER III.

THE PRIMORDIAL, OR CAMBRIAN AGE.

BETWEEN the time when *Eozoon Canadense* flourished in the seas of the Laurentian period, and the age which we have been in the habit of calling Primordial, or Cambrian, a great gap evidently exists in our knowledge of the succession of life on both of the continents, representing a vast lapse of time, in which the beds of the Upper Laurentian were deposited, and in which the Laurentian sediments were altered, contorted, and upheaved, before another immense series of beds, the Huronian, or Lower Cambrian, was formed in the bottom of the sea. *Eozoon* and its companions occur in the Lower Laurentian. The Upper Laurentian has afforded no evidence of life; and even those conditions from which we could infer life are absent. The Lowest Cambrian, as we shall see, presents only a few traces of living beings. Still, the physical history of this interval must have been most important. The wide level bottom of the Laurentian sea was broken up and thrown into those bold ridges which were to constitute the nuclei of the existing continents. Along the borders of these new-made lands intense volcanic eruptions broke forth, producing great quantities of lava and scoriæ and huge beds of conglomerate and volcanic ash, which are

characteristic features of the older Cambrian in both hemispheres. Such conditions, undoubtedly not favourable to life, seem to have prevailed, and extended their influence very widely, so that the sediments of this period are among the most barren in fossils of any in the crust of the earth. If any quiet undisturbed spots existed in which the Lower Laurentian life could be continued and extended in preparation for the next period, we have yet discovered few of them. The experience of other geological periods would, however, entitle us to look for such oases in the Lower Cambrian desert, and to expect to find there some connecting links between the life of the Eozoic and the very dissimilar fauna of the Primordial.

The western hemisphere, where the Laurentian is so well represented, is especially unproductive in fossils of the immediately succeeding period. The only known exception is the occurrence of Eozoon and of apparent casts of worm-burrows in rocks at Madoc in Canada, overlying the Laurentian, and believed to be of Huronian age, and certain obscure fossils of uncertain affinities, recently detected by Mr. Billings, in rocks supposed to be of this age, in Newfoundland. Here, however, the European series comes in to give us some small help. Gmbel has described in Bavaria a great series of gneissic rocks corresponding to the Laurentian, or at least to the lower part of it; above these are what he calls the Hercynian mica-slate and primitive clay-slate, in the latter of which

he finds a peculiar species of Eozoon, which he names *Eozoon Bavarium*. In England also the Longmynd groups of rocks in Shropshire and in Wales appears to be the immediate successor to the Upper Laurentian; and it has afforded some obscure "worm-burrows," or, perhaps, casts of sponges or fucoids, with a small shell of the genus *Lingulella*, and also fragments of crustaceans (*Palæopyge*). The "Fucoid Sandstones" of Sweden, believed to be of similar age, afford traces of marine plants and burrows of worms, while the Harlech beds of Wales have afforded to Mr. Hicks a considerable number of fossil animals, not very dissimilar from those of the Upper Cambrian. If these rocks are really the next in order to the Eozoic, they show a marked advance in life immediately on the commencement of the Primordial period. In Ireland, the curious *Oldhamia*, noticed below, appears to occur in rocks equally old. As we ascend, however, into the Middle and Upper parts of the Cambrian, the Menevian and *Lingula* flag-beds of Britain, and their equivalents in Bohemia and Scandinavia, and the Acadian and Potsdam groups of America, we find a rich and increasing abundance of animal remains, constituting the first Primordial fauna of Barrande.

The rocks of the Primordial are principally sandy and argillaceous, forming flags and slates, without thick limestones, and often through great thicknesses, very destitute of organic remains, but presenting some layers, especially in their upward extension, crowded

with fossils. These are no longer mere Protozoa, but include representatives of all the great groups of animals which yet exist, except the vertebrates. We shall not attempt any systematic classification of these; but, casting our dredge and tow-net into the Primordial sea, examine what we collect, rather in the order of relative abundance than of classification.

Over great breadths of the sea bottom we find vast numbers of little bivalve shells of the form and size of a finger-nail, fastened by fleshy peduncles imbedded in the sand or mud; and thus anchored, collecting their food by a pair of fringed arms from the minute animals and plants which swarm in the surrounding waters. These are the *Lingulæ*, from the abundance of which some of the Primordial beds have received in England and Wales the name of Lingula flags. In America, in like manner, in some beds near St. John, New Brunswick, the valves of these shells are so abundant as to constitute at least half of the material of the bed; and alike in Europe and America, *Lingula* and allied forms are among the most abundant Primordial fossils. The *Lingulæ* are usually reckoned to belong to the great sub-kingdom of mollusks, which includes all the bivalve and univalve shell-fish, and several other groups of creatures; but an able American naturalist, Mr. Morse, has recently shown that they have many points of resemblance to the worms; and thus, perhaps, constitute one of those curious old-fashioned "comprehensive" types, as they have been called, which present

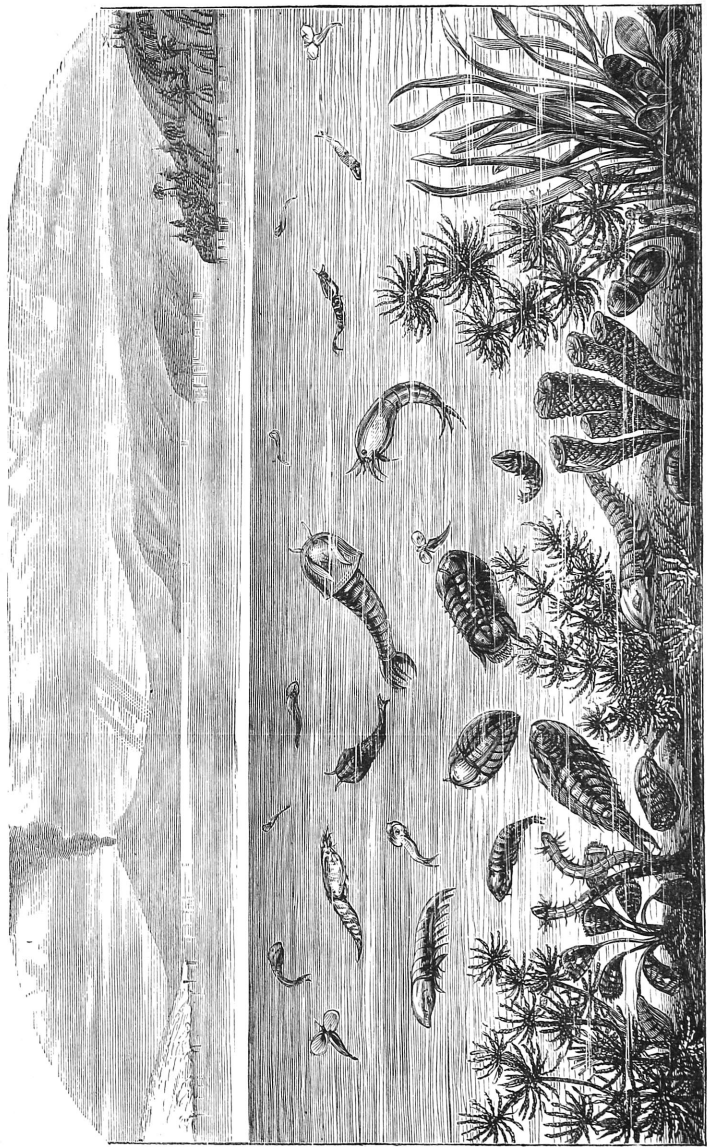


Fig. 8.—LIFE IN THE PRIMORDIAL SEA.

On the bottom are seen, proceeding from left to right, *Oldhamia antiqua*, *Lingule*, *Arenicola*, *Paradoxia*, *Paradoxia*, *Paradoxia*, *Histioderma*, *Agnostus*, *Oldhamia radiata*, *Alice*, and *Lingule*. In the water are *Hymenocaris*, different species of *Trilobites*, and *Pteropoda*.

resemblances to groups of creatures, in more modern times quite distinct from each other. He has also found that the modern *Lingulæ* are very tenacious of life, and capable of suiting themselves to different circumstances, a fact which, perhaps, has some connection with their long persistence in geological time. They are in any case members of the group of lamp-shells, creatures specially numerous and important in the earlier geological ages.

The *Lingulæ* are especially interesting as examples of a type of beings continued almost from the dawn of life until now; for their shells, as they exist in the Primordial, are scarcely distinguishable from those of members of the genus which still live. While other tribes of animals have run through a great number of different forms, these little creatures remain the same. Another interesting point is a most curious chemical relation of the *Lingula*, with reference to the material of its shell. The shells of mollusks generally, and even of the ordinary lamp-shells, are hardened by common limestone or carbonate of lime: the rarer substance, phosphate of lime, is in general restricted to the formation of the bones of the higher animals. In the case of the latter, this relation depends apparently on the fact that the albuminous substances on which animals are chiefly nourished require for their formation the presence of phosphates in the plant. Hence the animal naturally obtains phosphate of lime or bone-earth with its food, and its system is related to this chemi-

cal fact in such wise that phosphate of lime is a most appropriate and suitable material for its teeth and bones. Now, in the case of the lower animals of the sea, their food, not being of the nature of the richer land plants, but consisting mainly of minute algæ and of animals which prey on these, furnishes, not phosphate of lime, but carbonate. An exception to this occurs in the case of certain animals of low grade, sponges, etc., which, feeding on minute plants with siliceous cell-walls, assimilate the flinty matter and form a siliceous skeleton. But this is an exception of downward tendency, in which these animals approach to plants of low grade. The exception in the case of *Lingulæ* is in the other direction. It gives to these humble creatures the same material for their hard parts which is usually restricted to animals of much higher rank. The purpose of this arrangement, whether in relation to the cause of the deviation from the ordinary rule or its utility to the animal itself, remains unknown. It has, however, been ascertained by Dr. Hunt, who first observed the fact in the case of the Primordial *Lingulæ*, that their modern successors coincide with them, and differ from their contemporaries among the mollusks in the same particular. This may seem a trifling matter, but it shows in this early period the origination of the difference still existing in the materials of which animals construct their skeletons, and also the wonderful persistence of the *Lingulæ*, through all the geological ages, in the material of their shells. This is the more

remarkable, in connection with our own very slender acquaintance with the phenomenon, in relation either to its efficient or final causes.

Before leaving the *Lingulæ*, I may mention that Mr. Morse informs me that living specimens, when detached from their moorings, can creep like worms, leaving long furrows on the sand, and that they can also construct sand-tubes wherein to shelter themselves. This shows that some of the abundant "worm burrows" of the Primordial may have been the work of these curious little shell-fishes, as well as, perhaps, some of the markings which have been described under the name of *Eophyton*, and have been supposed, I think incorrectly, to be remains of land plants.

In addition to *Lingula* we may obtain, though rarely, lamp-shells of another type, that of the *Orthids*. These have the valves hinged along a straight line, in the middle of which is a notch for the peduncle, and the valves are often marked with ribs or striæ. The *Orthids* were content with limestone for their shells, and apparently lived in the same circumstances with the *Lingulæ*; and in the period succeeding the Primordial they became far more abundant. Yet they perished at an early stage of the world's progress, and have no representatives in the modern seas.

In many parts of the Primordial ocean the muddy bottom swarmed with crustaceans, relatives of our shrimps and lobsters, but of a form which differs so much from these modern shell-fishes that the question

of their affinities has long been an unsettled one with zoologists. Hundreds of species are known, some almost microscopic in size, others a foot in length. All are provided with a broad flat horseshoe-shaped head-plate, which, judging from its form and a comparison with the modern king-crabs or horse-shoe-crabs, must have been intended as a sort of mud-plough to enable them to excavate burrows or hide themselves in the slimy ooze of the ocean bed. On the sides of this buckler are placed the prominent eyes, furnished with many separate lenses, on precisely the same plan with those of modern crustaceans and insects, and testifying, as Buckland long ago pointed out, to the identity of the action of light in the ancient and the modern seas. The body was composed of numerous segments, each divided transversely into three lobes, whence they have received the name of *Trilobites*, and the whole articulated, so that the creature could roll itself into a ball, like the modern slaters or wood-lice, which are not very distant relatives of these old crustaceans.* The limbs of *Trilobites* were long unknown, and it was even doubted whether they had any; but recent discoveries have shown that they had a series of flat limbs useful both for swimming and creeping. The *Trilobites*, under many specific and generic forms, range from

* Woodward has recently suggested affinities of *Trilobites* with the *Isopods* or equal-footed crustaceans, on the evidence of a remarkable specimen with remains of feet described by Billings.

the Primordial to the Carboniferous rocks, but are altogether wanting in the more recent formations and in the modern seas. The Trilobites lived on muddy bottoms, and their remains are extremely abundant in shaly and slaty beds, though found also in limestone and sandstone. In the latter they have left most curious traces of their presence in the trails which they have produced. Some of the most ancient sandstones have their surfaces covered with rows of punctured impressions (*Protichnites*, first foot-prints), others have strange series of transverse grooves with longitudinal ones at the side (*Olimactichnites*, ladder foot-prints); others are oval burrows, marked with transverse lines and a ridge along the middle (*Rusichnites*, wrinkle foot-prints). All of these so nearly resemble the trails and tracks of modern king-crabs that there can be little doubt as to their origin. Many curious striated grooves and bifid marks, found on the surfaces of Primordial beds, and which have been described as plants, are probably only the marks of the oral organs or feet of these and similar creatures, which passed their lives in grubbing for food in the soft, slimy ooze, though they could, no doubt, like the modern king-crabs, swim when necessary. Some still more shrimp-like creatures, *Hymenocaris*, which are found with them, certainly had this power.

A lower type of annulose or ringed animal than that of the Trilobites, is that of the worms. These creatures cannot be preserved in a fossil state, except in the case of those which inhabit calcareous tubes: but

the marks which their jointed bodies and numerous side-bristles leave on the sand and mud may, when buried under succeeding sediments, remain; and extensive surfaces of very old rocks are marked in this way, either with cylindrical burrows or curious trails with side scratches looking like pinnate leaves. These constitute the genus *Crusiana*, while others of more ordinary form belong to the genus *Arenicolites*, so named from the common *Arenicola*, or lobworm, whose burrows they are supposed to resemble. Markings referable to seaweed also occur in the Primordial rocks, and also some grotesque and almost inexplicable organisms known as *Oldhamia*, which have been chiefly found in the Primordial of Ireland. One of the most common forms consists of a series of apparently jointed threads disposed in fan-like clusters on a central stem (*Oldhamia antiqua*). Another has a wider and simpler fan-like arrangement of filaments. These have been claimed by botanists as algæ, and have been regarded by zoologists as minute Zoophytes, while some more sceptical have supposed that they may be mere inorganic wrinklings of the beds. This last view does not, however, seem tenable. They are, perhaps, the predecessors of the curious *Graptolites*, which we shall have to represent in the Silurian.

Singularly enough, Foraminifera, the characteristic fossils of the Laurentian, have been little recognised in the Primordial, nor are there any limestones known so massive as those of the former series. There are, however, a number of remarkable organisms, which

have usually been described as sponges, but are more probably partly of the nature of sponges and partly of that of Foraminifera. Of this kind are some of the singular conical fossils described by Billings as *Archæocyathus*, and found in the Primordial limestone of Labrador. They are hollow within, with radiating pores and plates, calcareous in some, and in others with siliceous spicules like those of modern sponges. Some of them are several inches in diameter, and they must have grown rooted in muddy bottoms, in the manner of some of the deep-sea sponges of modern times. One species at least of these creatures was a true Foraminifer, allied, though somewhat distantly, to Eozoon. In some parts of the Primordial sandstones, curious funnel-shaped casts in sand occur, sometimes marked with spiral lines. The name *Histioderma* has been given to some of these, and they have been regarded as mouths of worm-burrows. Others of larger size have been compared to inverted stumps of trees. If they were produced by worms, some of these must have been of gigantic size, but Billings has recently suggested that they may be casts of sponges that lived like some modern species imbedded in the sand. In accordance with this view I have represented these curious objects in the engraving. On the whole, the life of these oldest Palæozoic rocks is not very abundant; but there are probably representatives of three of the great subdivisions of animals—or, as some would reckon them, of four—the Protozoa, the Radiata (Cœlenterata), the Mollusca, and the

Annulosa. And it is most interesting thus to find in these very old rocks the modern subdivisions of animals already represented, and these by types some of them nearly allied to existing inhabitants of the seas. I have endeavoured in the engraving to represent some of the leading forms of marine life in this ancient period.

Perhaps one of the most interesting discoveries in these rocks is that of rain-marks and shrinkage-cracks, in some of the very oldest beds—those of the Longmynd in Shropshire. On the modern muddy beach any ordinary observer is familiar with the cracks produced by the action of the sun and air on the dried surfaces left by the tides. Such cracks, covered by the waters of a succeeding tide, may be buried in newer silt, and once preserved in this way are imperishable. In like manner, the pits left by passing showers of rain on the mud recently left bare by the tide may, when the mud has dried, become sufficiently firm to be preserved. In this way we have rain-marks of various geological ages; but the oldest known are those of the Longmynd, where they are associated both with ripple-marks and shrinkage-cracks. We thus have evidence of the action of tides, of sun, and of rain, in these ancient periods just as in the present day. Were there no land animals to prowl along the low tidal flats in search of food? Were there no herbs or trees to drink in the rains and flourish in the sunshine? If there were, no bone or footprint on the shore, or drifted leaf or branch, has yet revealed their existence to the eyes of geologists.

The beds of the Primordial age exist in England, in Bohemia, in Sweden and Norway, and also in North America. They appear to have been deposited along the shores of the old Laurentian continent, and probably some of them indicate very deep water. The Primordial rocks are in many parts of the world altered and hardened. They have often assumed a slaty structure, and their bedding, and the fossils which they contain, are both affected by this. The usual view entertained as to what is called slaty structure is, that it depends on pressure, acting on more or less compressible material in some direction usually different from that of the bedding. Such pressure has the effect of arranging all the flat particles—as scales of mica, etc.—in planes parallel to the compressing surface. Hence, if much material of this kind is present in the sediment, the whole rock assumes a fissile character, causing it to split readily into thin plates. That such yielding to pressure has actually taken place is seen very distinctly in microscopic sections of some slaty rocks, which often show not only a laminated structure, but an actual crumpling on a small scale, causing them to assume almost the aspect of woody fibre. Such rocks often remind a casual observer of decaying trunks of trees, and sections of them under the microscope show the most minute and delicate crumpling. It is also proved by the condition of the fossils the beds contain. These are often distorted, so that some of them are lengthened and others shortened, and if specimens were

selected with that view, it would be quite easy to suppose that those lengthened by distortion are of different species from those distorted so as to be shortened. Slaty cleavage and distortion are not, however, confined to Primordial rocks, but occur in altered sediments of various ages.

The Primordial sediments must have at one time been very widely distributed, and must have filled up many of the inequalities produced by the rending and contortion of the Laurentian beds. Their thicker and more massive portions are, however, necessarily along the borders of the Laurentian continents, and as they in their turn were raised up into land, they became exposed to the denuding action first of the sea, and afterwards of the rain and rivers, and were so extensively wasted away that only in a few regions do large areas of them remain visible. That of Bohemia has afforded to Barrande a great number of most interesting fossils. The rocks of St. David's in Wales, those of Shropshire in England, and those of Wicklow in Ireland are also of great interest; and next to these in importance are, perhaps, the Huronian and Acadian groups of North America, in which continent—as for example in Nova Scotia and in some parts of New England—there are extensive areas of old metamorphic rocks whose age has not been determined by fossils, but which may belong to this period.

The question of division lines of formations is one much agitated in the case of the Cambrian rocks. Whether certain beds are to be called Cambrian or

Silurian has been a point greatly controverted; and the terms Primordial and Primordial Silurian have been used as means to avoid the raising of this difficulty. Many of our division lines in geology are arbitrary and conventional, and this may be the case with that between the Primordial and Silurian, the one age graduating into the other. There appears to be, however, the best reason to recognise a distinct Cambrian period, preceding the two great periods, those of the second and third faunas of Barrande, to which the term Silurian is usually applied. On the other hand, in so far as our knowledge extends at present, a strongly marked line of separation exists between the Laurentian and Primordial, the latter resting on the edges of the former, which seems then to have been as much altered as now. Still a break of this kind may be, perhaps must be, merely local; and may vary in amount. Thus, in some places we find rocks of Silurian and later ages resting directly on the Laurentian, without the intervention of the Primordial. In any case, where a line of coast is steadily sinking, each succeeding deposit will overlap that which went before; and this seems to have been the case with the Laurentian shore when the Primordial and Silurian were being deposited. Hence over large spaces the Primordial is absent, being probably buried up, except where exposed by denudation at the margin of the two formations.

This occurs in several parts of Canada, while the Laurentian rocks have evidently been subjected to metamorphism and long-continued weathering before

the Lower Silurian were deposited ; and in some cases the latter rest on weather-worn and pitted surfaces, and are filled with angular bits of the underlying rock, as well as with drift-shells which have been cast on these old Laurentian shores ; while in other cases the Silurian rests on smooth water-worn Laurentian rocks, and is filled at the junction with well-rounded pebbles and grains of sand which have evidently been subjected to a more thorough attrition than those of the present beach. With respect to the line of division between the Primordial and the next succeeding rocks, it will be seen that important movements of the continents occurred at the close of the Cambrian, and in some places the Cambrian rocks have been much disturbed before the deposition of the Lower Silurian.

Seated on some ancient promontory of the Laurentian, and looking over the plain which, in the Primordial and Lower Silurian periods was the sea, I have often wished for some shred of vegetable matter to tell what lived on that land when the Primordial surf beat upon its shore, and washed up the Trilobites and Brachiopods of those old seas ; but no rock has yet taken up its parable to reveal the secret, and the Primordial is vocal only with the old story : " And God said, Let the waters swarm with swarming living things, and it was so." So our picture of the period may represent a sea-bottom swarming with animals of low grade, some sessile, some locomotive ; and we may merely suppose a distant shore with vegetation dimly seen, and active volcanoes ; but a shore on which no

foot of naturalist has yet trod to scan its productions.

Very different estimates have been formed of the amount of life in this period, according to the position given to its latest limit. Taking some of the more modern views of this subject, we might have included among the Primordial animals many additional creatures, which we prefer noticing in the Silurian, since it may at least be affirmed that their head-quarters were in that age, even if they had a beginning in the Primordial. It may be interesting here, however, to note the actual amount of life known to us in this period, taken in its largest scope. In doing this, I shall take advantage of an interesting table given by Dr. Bigsby,* and representing the state of knowledge in 1868, and shall group the species in such a manner as to indicate the relative abundance of distinct types of structure. We find then—

Plants (all, or nearly all, supposed to be seaweeds, and some, probably, mere tracks or trails of animals)	. . .	22 species.
Sponges, and similar creatures	. . .	27 "
Corals and their allies	. . .	6 "
Starfishes and their allies	. . .	4 "
Worms	. . .	29 "
Trilobites and other crustaceans	. . .	442 "
Lamp-shells and other molluscoids	. . .	193 "
Common bivalve mollusks	. . .	12 "
Common univalve mollusks and their allies	. . .	172 "
Higher mollusks, nautili, cuttle-fishes, etc.	. . .	65 "
In all	. . .	972 "

* "Thesaurus Siluricus."

Now in this enumeration we observe, in the first place, a representation of all the lower or invertebrate groups of the waters. We have next the remarkable fact that the Radiata of Cuvier, the lowest and most plant-like of the marine animals, are comparatively slenderly represented, yet that there are examples of their higher as well as of their lower forms. We have the further fact that the crustaceans, the highest marine animals of the annulose type, are predominant in the waters; and that in the mollusks the highest and lowest groups are most plentiful, the middle less so. The whole number of species is small, and this may arise either from our having here reached an early period in the history of life, or from our information being defective. Both are probably true. Still, of the animals known, we cannot say that the proportions of the different kinds depend on defective knowledge. There is no reason, for example, why corals should not have been preserved as well as Trilobites, or why Brachiopods should have been preserved rather than ordinary bivalves. The proportions, therefore, it may be more safe to reason from than the aggregate. In looking at these proportions, and comparing them with those of modern seas, we are struck with the great number of species representing some types either now extinct or comparatively rare: the Trilobites and Brachiopods more particularly. We are astonished at the enormous preponderance of these two groups, and especially of the Trilobites. Further, we observe that while some forms, like

Lingula and Nautilus, have persisted down to modern times, others, like the Trilobites and Orthids, perished very early. In all this we can dimly perceive a fitness of living things to physical conditions, a tendency to utilise each type to the limit of its capacities for modification, and then to abandon it for something higher; a tendency of low types to appear first, but to appear in their highest perfection and variety; a sudden apparition of totally diverse plans of structure subserving similar ends simultaneously with each other, as for instance those of the Mollusk and the Crustacean; the appearance of optical and mechanical contrivances, as for example the compound eyes of the Trilobite and the swimming float of the Orthoceras, in all their perfection at first, just as they continue to this day in creatures of similar grade. That these and other similar things point to a uniform and far-reaching plan, no rational mind can doubt; and if the world had stopped short in the Primordial period, and attained to no further development, this would have been abundantly apparent; though it shines forth more and more conspicuously in each succeeding page of the stony record. How far such unity and diversity can be explained by the modern philosophy of a necessary and material evolution out of mere death and physical forces, and how far it requires the intervention of a Creative mind, are questions which we may well leave with the thoughtful reader, till we have traced this history somewhat further.

CHAPTER IV.

THE LOWER AND UPPER SILURIAN AGES.

By English geologists, the great series of formations which succeeds to the Cambrian is usually included under the name Silurian System, first proposed by Sir Roderick Murchison. It certainly, however, consists of two distinct groups, holding the second and third faunas of Barrande. The older of the two, usually called the Lower Silurian, is the Upper Cambrian of Sedgwick, and may properly be called the *Siluro-Cambrian*. The newer is the true Silurian, or Silurian proper—the Upper Silurian of Murchison. We shall in this chapter, for convenience, consider both in connection, using occasionally the term Lower Silurian as equivalent to *Siluro-Cambrian*. The Silurian presents us with a definite physical geography, for the northern hemisphere at least; and this physical geography is a key to the life conditions of the time. The North American continent, from its great unbroken area, affords, as usual, the best means of appreciating this. In this period the northern currents, acting perhaps in harmony with old Laurentian outcrops, had deposited in the sea two long submarine ridges, running to the southward from the extreme ends of the Laurentian nucleus, and constituting the foundations of the present ridges of the Rocky

Mountains and the Alleghanies. Between these the extensive triangular area now constituting the greater part of North America, was a shallow oceanic plateau, sheltered from the cold polar currents by the Laurentian land on the north, and separated by the ridges already mentioned from the Atlantic and Pacific. It was on this great plateau of warm and sheltered ocean that what we call the Silurian fauna lived; while of the creatures that inhabited the depths of the great bounding oceans, whose abysses must have been far deeper and at a much lower temperature, we know little. During the long Silurian periods, it is true, the great American plateau underwent many revolutions; sometimes being more deeply submerged, and having clear water tenanted by vast numbers of corals and shell-fishes, at others rising so as to become shallow and to receive deposits of sand and mud; but it was always distinct from the oceanic area without. In Europe, in like manner, there seems to have been a great internal plateau bounded by the embryo hills of Western Europe on the west, and harbouring a very similar assemblage of creatures to those existing in America.

Further, during these long periods there were great changes, from a fauna of somewhat primordial type up to a new order of things in the Upper Silurian, tending toward the novelties which were introduced in the succeeding Devonian and Carboniferous. We may, in the first place, sketch these changes as they occurred on the two great continental

plateaus, noting as we proceed such hints as can be obtained with reference to the more extensive oceanic spaces.

Before the beginning of the age, both plateaus seem to have been invaded by sandy and muddy sediments charged at some periods and places with magnesian limestone; and these circumstances were not favourable to the existence or preservation of organic remains. Such are the Potsdam and Calciferous beds of America and the Tremadoc and Llandeilo beds of England. The Potsdam and Tremadoc are by their fossils included in the Cambrian, and may at least be regarded as transition groups. It is further to be observed, in the case of these beds, that if we begin at the west side of Europe and proceed easterly, or at the east side of America and proceed westerly, they become progressively thinner, the greater amount of material being deposited at the edges of the future continents; just as on the sides of a muddy tideway the flats are higher, and the more coarse sediment deposited near the margin of the channel, and fine mud is deposited at a greater distance and in thinner beds. The cause, however, on the great scale of the Atlantic, was somewhat different, ancient ridges determining the border of the channel. This statement holds good not only of these older beds, but of the whole of the Silurian, and of the succeeding Devonian and Carboniferous, all deposited on these same plateaus. Thus, in the case of the Silurian in England and Wales, the whole series is more than 20,000 feet

thick, but in Russia, it is less than 1,000 feet. In the eastern part of America the thickness is estimated at quite as great an amount as in Europe, while in the region of the Mississippi the Silurian rocks are scarcely thicker than in Russia, and consist in great part of limestones and fine sediments, the sandstones and conglomerates thinning out rapidly eastward of the Appalachian Mountains.

In both plateaus the earlier period of coarse accumulations was succeeded by one in which was clear water depositing little earthy sediment, and this usually fine; and in which the sea swarmed with animal life, from the *débris* of which enormous beds of limestone were formed—the Trenton limestone of America and the Bala limestone of Europe. The fossils of this part of the series open up to us the head-quarters of Lower Silurian life, the second great fauna of Barrande, that of the Upper Cambrian of Sedgwick; and in America more especially, the Trenton and its associated limestones can be traced over forty degrees of longitude; and throughout the whole of this space its principal beds are composed entirely of comminuted corals, shells, and crinoids, and studded with organisms of the same kinds still retaining their forms. Out of these seas, in the European area, arose in places volcanic islets, like those of the modern Pacific.

In the next succeeding era the clear waters became again invaded with muddy and sandy sediments, in various alternations, and with occasional bands of lime-

stone, constituting the Caradoc beds of Britain and the Utica and Hudson River groups of America. During the deposition of these, the abounding life of the Siluro-Cambrian plateaus died away, and a middle group of sandstones and shales, the Oneida and Medina of America and the Mayhill of England, form the base of the Upper Silurian.

But what was taking place meanwhile in the oceanic areas separating our plateaus? These were identical with the basins of the Atlantic and Pacific, which already existed in this period as depressions of the earth's crust, perhaps not so deep as at present. As to the deposits in their deeper portions we know nothing; but on the margin of the Atlantic area are some rocks which give us at least a little information.

In the later part of the Cambrian period the enormous thickness of the Quebec group of North America appears to represent a broad stripe of deep water parallel to the eastern edge of the American plateau, and in which an immense thickness of beds of sand and mud was deposited with very few fossils, except in particular beds, and these of a more primordial aspect than those of the plateau itself. These rocks no doubt represent the margin of a deep Atlantic area, over which cold currents destructive of life were constantly passing, and in which great quantities of sand and mud, swept from the icy regions of the North, were continually being laid. The researches of Dr. Carpenter and Dr. Wyville Thomson show us that there are at present cold areas in the deeper

parts of the Atlantic, on the European side, as we have long known that they exist at less depths on the American side; and these same researches, with the soundings on the American banks, show that sand and gravel may be deposited not merely on shallows, but in the depths of the ocean, provided that these depths are pervaded by cold and heavy currents capable of eroding the bottom, and of moving coarse material. The Quebec group in Canada and the United States, and the metalliferous Lower Silurian rocks of Nova Scotia and Newfoundland, destitute of great marine limestones and coral reefs, evidently represent deep and cold-water areas on the border of the Atlantic plateau.

At a later period, the beginning of the Upper Silurian, the richly fossiliferous and exceptional deposits of the Island of Anticosti, formed in the deep hollow of the Gulf of St. Laurence, show that when the plateau had become shallowed up by deposition and elevation, and converted into desolate sandbanks, the area of abundant life was transferred to the still deep Atlantic basin and its bordering bays, in which the forms of Lower Silurian life continued to exist until they were mixed up with those of the Upper Silurian.

If we turn now to these latter rocks, and inquire as to their conditions on our two great plateaus, we shall find a repetition of changes similar to those which occurred in the times preceding. The sandy shallows of the earlier part of this period give place to wide

oceanic areas similar to those of the Lower Silurian, In these we find vast and thick coral and shell limestones, the Wenlock of England and Niagara of America, as rich in life as the limestones of the Lower Silurian, and with the generic and family forms similar, but the species for the most part different. In America these limestones were followed by a singularly shallow condition of the plateau, in which the surface was so raised as at times to be converted into separate salt lakes in which beds of salt were deposited. On both plateaus there were alternations of oceanic and shallow conditions, under which the Lower Helderberg and Ludlow beds, the closing members of the Silurian, were laid down. Of the Atlantic beds of this period we know little, except that the great limestones appear to be wanting, and to be replaced by sandy and muddy deposits, in some parts at least of the margins of the area. In some portions also of the plateaus and their margins, extensive volcanic outbursts seem to have occurred; so that the American plateau presented, at least in parts, the aspect of a coral sea with archipelagoes of volcanic islands, the ejections from which became mixed with the aqueous deposits forming around them.

Having thus traced the interesting series of geographical conditions indicated by the Silurian series, we may next take our station on one of the submerged plateaus, and inquire as to the new forms of life now introduced to our notice; and in doing so shall include the life of both the Lower and Upper Silurian.

First, we may remark the vast abundance and variety of corals. The polyps, close relatives of the common sea-anemone of our coasts, which build up our modern coral reefs, were represented in the Silurian seas by a great number of allied yet different forms, equally effectual in the great work of secreting carbonate of lime in stony masses, and therefore in

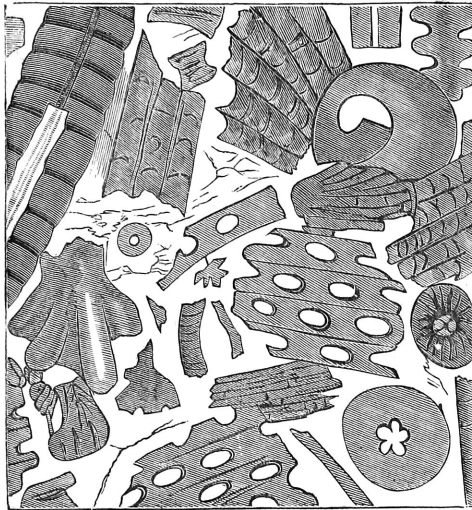


Fig. 9.—Fragment of Lower Silurian Limestone, sliced and magnified ten diameters, showing the manner in which it is made up of fragments of corals, crinoids, and shells. (From a paper on the Microscopic Structure of Canadian Limestone, "Canadian Naturalist.")

the building-up of continents. Let us note some of the differences. In the first place, whereas our modern coral-workers can show us but the topmost pinnacles of their creations, peeping above the surface of the

sea in coral reefs and islands, the work of the coral animals of the Silurian has been finished, by these limestones being covered with masses of new sediment consolidated into hard rock, and raised out of the sea to constitute a part of the dry land. In the Silurian limestones we thus have, not merely the coral reefs, but the wide beds of comminuted coral, mixed with the remains of other animals, which are necessarily accumulated in the ocean bed around the reefs and islands. Further, these beds, which we might find loose and unconsolidated in the modern sea, have their fragments closely cemented together in the old limestones. The nature of this difference can be well seen by comparing a fragment of modern coral or shell limestone from Bermuda, with a similar fragment of the Trenton limestone, both being sliced for examination under the microscope. The old limestone is black or greyish, the modern one is nearly white, because in the former the organic matter in the animal fragments has been carbonised or converted into coaly and bituminous matter. The old limestone is much more dense and compact, partly because its materials have been more closely compressed by superincumbent weight, but chiefly because calcareous matter in solution in water has penetrated all the interstices, and filled them up with a deposit of crystalline limestone. In examining a slice, however, under the microscope, it will be seen that the fragments of corals and other organisms are as distinct and well preserved as in the crumbling modern rock, except that they are perfectly

imbedded in a paste of clear transparent limestone, or rather calcareous spar, infiltrated between them. I have examined great numbers of slices of these limestones, ever with new wonder at the packing of the organic fragments which they present. The hard marble-like limestones used for building in the Silurian districts of Europe and America, are thus in most cases consolidated masses of organic fragments.

In the next place, the animals themselves must have differed somewhat from their modern successors. This we gather from the structure of their stony cells, which present points of difference indicating corresponding difference of detail in the soft parts. Zoologists thus separate the rugose or wrinkled corals and the tabulate or floored corals of the Silurian from those of the modern seas. The former must have been more like the ordinary coral animals; the latter were very peculiar, more especially in the close union of the cells, and in the transverse floors which they were in the habit of building across these cells as they grew in height. They presented, however, all the forms of our modern corals. Some were rounded and massive in form, others delicate and branching. Some were solitary or detached, others aggregative in communities. Some had the individual animals large and probably showy, others had them of microscopic size. Perhaps the most remarkable of all is the American *Beatricea*,* which grew like a great trunk of a tree

* First described by Mr. Billings. It has been regarded as a plant, and as a cephalopod shell; but I believe it was a coral allied to *Cystiphyllum*.

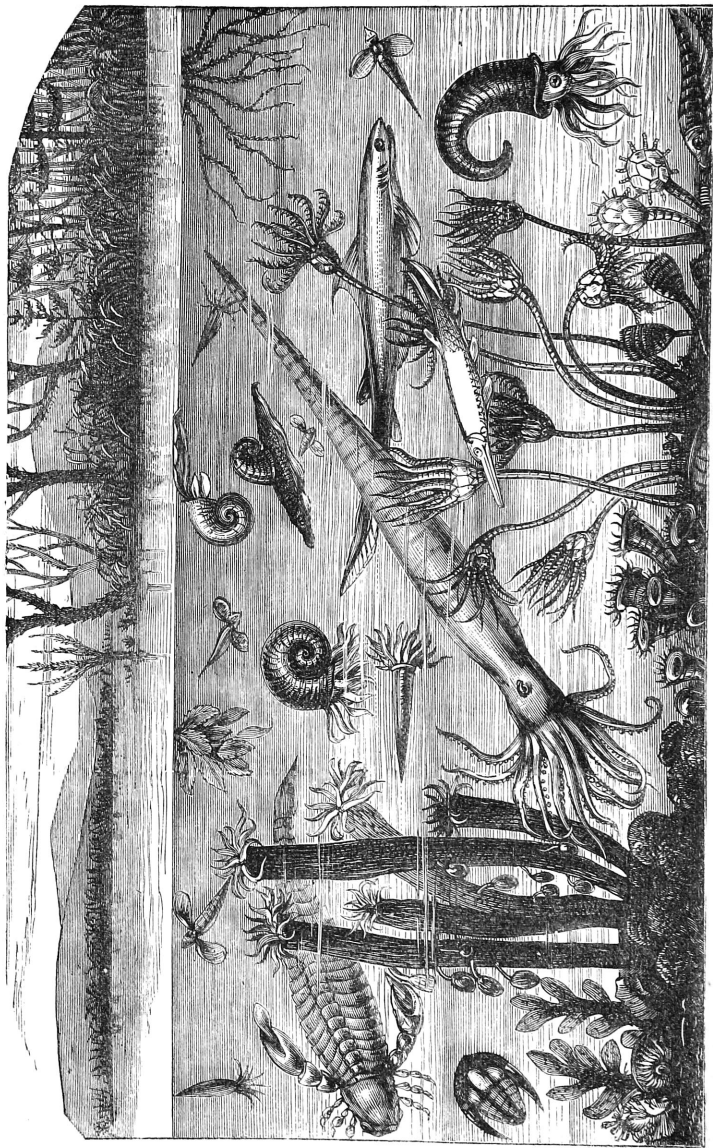


FIG. 10.—LIFE IN THE SILURIAN AGE.

On the bottom are seen, proceeding from left to right, Corals (*Stenopora* and *Beudanticeras*) and a Gastropod; *Orthoceras*; Coral (*Petratia*); Crinoids, *Livingstonia*, and Cystideans; a Trilobite and *Cyrtolites*. In the water is a large *Pterigodus*, and under it a *Trianaclaus*. Further on, are Cephalopods, a Heteropod, and Fishers. At the surface, *Phyllograptus*, *Graptolithus*, and *Ballerophon*. On the land, *Lepidodendron*, *Psilotum*, and *Prototascites*.

twenty feet or more in height, its solitary animal at the top like a pillar-saint, though no doubt more appropriate and comfortable; and multitudes of delicate and encrusting corals clinging like mosses or lichens to its sides. This creature belongs to the very middle of the Silurian, and must have lived in great depths, undisturbed by swell or breakers, and sheltering vast multitudes of other creatures in its stony colonnades.

Lastly, the Silurian corals flourished in latitudes more boreal than their modern representatives. In both hemispheres as far north as Silurian limestones have been traced, well-developed corals have been found. On the great plateaus sheltered by Laurentian ridges to the north, and exposed to the sun and to the warmer currents of the equatorial regions, they flourished most grandly and luxuriantly: but they lived also north of the Laurentian bands in the Arctic Sea basins, though probably in the shallower and more sheltered parts. Undoubtedly the geographical arrangements of the Silurian period contributed to this. We have already seen how peculiarly adapted to an exuberant marine life were the submerged continents of the period; and there was probably little Arctic land producing icebergs to chill the seas. The great Arctic currents, which then as now flowed powerfully toward the equator, must have clung to the deeper parts of the ocean basins, while the return waters from the equator would spread themselves widely over the surface; so that wherever the Arctic Seas presented areas a little elevated out of the cold bottom water,

there might be suitable abodes for coral animals. It has been supposed that in the Silurian period the sea might have derived some appreciable heat from the crust of the earth below, and astronomical conditions have been suggested as tending to produce changes of climate; but it is evident that whatever weight may be due to these causes, the observed geographical conditions are sufficient to account for the facts of the case. It is also to be observed, that we cannot safely infer the requirements as to temperature of Silurian coral animals from those of the tenants of the modern ocean. In the modern seas many forms of life thrive best and grow to the greatest size in the colder seas; and in the later tertiary period there were elephants and rhinoceroses sufficiently hardy to endure the rigours of an Arctic climate. So there may have been in the Silurian seas corals of much less delicate constitution than those now living.

Next to the corals we may place the crinoids, or stone-lilies—creatures abounding throughout the Silurian seas, and realizing a new creative idea, to be expanded in subsequent geological time into all the multifarious types of star-fishes and sea-urchins. A typical crinoid, such as the *Glyptocrinus* of the Lower Silurian, consists of a flexible jointed stem, sometimes several feet in length, composed of short cylindrical discs, curiously articulated together, a box-like body on top made up of polygonal pieces attached to each other at the edges, and five radiating jointed arms furnished with branches and branchlets, or fringes, all

articulated and capable of being flexed in any direction. Such a creature has more the aspect of a flower than of an animal ; yet it is really an animal, and subsists by collecting with its arms and drifting into its mouth minute creatures floating in the water. Another group, less typical, but abundantly represented in the Silurian seas, is that of the Cystideans, in which the body is sack-like, and the arms few and sometimes attached to the body. They resemble the young or larvæ of crinoids. In the modern seas the crinoids are extremely few, though dredging in very deep water has recently added to the number of known species ; but in the Silurian period they had their birth, and attained to a number and perfection not afterwards surpassed. Perhaps the stone-lilies of the Upper Silurian rocks of Dudley, in England, are the most beautiful of Palæozoic animals. Judging from the immense quantities of their remains in some limestones, wide areas of the sea bottom must have been crowded with their long stalks and flower-like bodies, presenting vast submarine fields of these stony water-lilies.

Passing over many tribes of mollusks, continued or extended from the Primordial—and merely remarking that the lamp-shells and the ordinary bivalve and univalve shell-fishes are all represented largely, more especially the former group, in the Silurian—we come to the highest of the Mollusca, represented in our seas by the cuttle-fishes and nautili, creatures which, like the crinoids, may be said to have had their birth in

the Silurian, and to have there attained to some of their grandest forms. The modern pearly nautilus shell, well known in every museum, is beautifully coiled in a disc-like form, and when sliced longitudinally shows a series of partitions dividing it into chambers, air-tight, and serving as a float to render the body of the creature independent of the force of gravity. As the animal grows it retracts its body toward the front of the shell, and forms new partitions, so that the buoyancy of the float always corresponds with the weight of the animal; while by the expansion and contraction of the body and removal of water from a tube or syphon which traverses the chambers, or the injection of additional water, slight differences can be effected, rendering the creature a very little lighter or heavier than the medium in which it swims. Thus practically delivered from the encumbrance of weight, and furnished with long flexible arms provided with suckers, with great eyes and a horny beak, the nautilus becomes one of the tyrants of the deep, creeping on the bottom or swimming on the surface at will, and everywhere preying on whatever animals it can master. Fortunately for us, as well as for the more feeble inhabitants of the sea, the nautili are not of great size, though some of their allies, the cuttle-fishes, which, however, want the floating apparatus, are sufficiently powerful to be formidable to man. In the Silurian period, however, there were not only nautili like ours, but a peculiar kind of straight nautilus—the *Orthocer-*

atites—which sometimes attained to gigantic size. The shells of these creatures may be compared to those of nautili straightened out, the chambers being placed in a direct line in front of each other. A great number of species have been discovered, many quite insignificant in size, but others as much as twelve feet in length and a foot in diameter at the larger end. Indeed, accounts have been given of individuals of much larger growth. These large *Orthoceratites* were the most powerful marine animals known to us in the Silurian, and must have been in those days the tyrants of the seas.*

Among the crustaceans, or soft shell-fishes of the Silurian, we meet with the *Trilobites*, continued from the Primordial in great and increasing force, and represented by many and beautiful species; while an allied group of shell-fishes of low organization but gigantic size, the *Eurypterids*, characteristic of the Upper Silurian, were provided with powerful limbs, long flexible bodies, and great eyes in the front of the head, and were sometimes several feet in length. Instead of being mud grovellers, like the *Trilobites* and modern king-crabs, these *Eurypterids* must have been swimmers, careering rapidly through the water, and probably active and predaceous. There were

* Zoologists will observe that I have, in the illustration, given the *Orthoceras* the arms rather of a cuttle-fish than of a nautilus. The form of the outer chamber of the shell, I think, warrants this view of the structure of the animal, which must have been formed on a very comprehensive type.

also great multitudes of those little crustaceans which are inclosed in two horny or shelly valves like a bivalve shell-fish, and the remains of which sometimes fill certain beds of Silurian shale and limestone.

No remains found in the Silurian rocks have been more fertile sources of discussion than the so-called *Graptolites*, or written stones—a name given long ago by Linnæus, in allusion to the resemblance of some species having rows of cells on one side, to minute lines of writing. These little bodies usually appear as black coaly stains on the surface of the rock, showing a slender stem or stalk, with a row of little projecting cells at one side, or two rows, one on each side. The more perfect specimens show that, in many of the species at least, these fragments were branches of a complex organism spreading from a centre; and at this centre there is sometimes perceived a sort of membrane connecting the bases of the branches, and for which various uses have been conjectured. The branches themselves vary much in different species. They may be simple or divided, narrow, or broad and leaf-like, with one row of cells, or two rows of cells. Hence arise generic distinctions into single and double graptolites, leaf and tree graptolites, net graptolites, and so on. But while it is easy to recognise these organisms, and to classify them in species and genera, it is not so easy to say what their affinities are with modern things. They are exclusively Silurian, disappearing altogether at the close of this period, and, so far as we know, not

succeeded by any similar creatures serving to connect them with modern forms. Hence the most various conjectures as to their nature. They have been supposed to be plants, and have been successively referred to most of the great divisions of the lower animals. Most recently they have been regarded by Hall, Nicholson,* and others, who have studied them most attentively, as zoophytes or hydroids allied to the Sertulariæ, or tooth-corallines and sea-fir-corallines of our coasts, to the cell-bearing branches of which their fragments bear a very close resemblance. In this case, each of the little cells or teeth at the sides of the fibres must have been the abode of a little polyp, stretching out its tentacles into the water, and enjoying a common support and nutrition with the other polyps ranged with it. Still the mode of life of the community of branching stems is uncertain. In some species there is a little radicle or spike at the base of the main stem, which may have been a means of attachment. In others the hollow central disk has been conjectured to have served as a float. Occurring as the specimens do usually in shales and slates, which must have been muddy beds, they could not have been attached to stones or rocks, and they must have lived in clear water, either seated on the surface of the mud, attached to sea-weeds, or floating freely by means of hollow disks filled with air. After much thought on their structure and mode of oc-

* See also an able paper by Carruthers, in the *Geological Magazine*, vol. v., p. 64.

currence, I am inclined to believe that in their younger stages they were attached, but by a very slender thread; that at a more advanced stage they became free, and acquiring a central membranous disk filled with air, floated by means of this at the surface, their long branches trailing in the waters below. They would thus be, with reference to their mode of life, though not to the details of their structure, prototypes of the modern Portuguese man-of-war, which now drifts so gaily over the surface of the warmer seas. I have represented them in this attitude; but in case I should be mistaken, the reader may imagine it possible that they may be adhering to the lower surface of floating tangle. The headquarters of the Graptolites seem to be in the upper part of the Cambrian, and in the Siluro-Cambrian, and they are widely distributed in Europe, in America, and in Australia. This very wide distribution of the species is probably connected with their floating and oceanic habits.

Lastly, just as the Silurian period was passing away, we find a new thing in the earth—vertebrate animals, represented by several species of shark-like fishes, which came in here as forerunners of the dynasty of the vertebrates, which from that day to this have been the masters of the world. These earliest vertebrates are especially interesting as the first known examples of a plan of structure which culminates only in man himself. They appear to have had cartilaginous skeletons; and in this and

their shagreen-like skin, strong bony spines, and trenchant teeth, to have much resembled our modern sharks, or rather the dog-fishes, for they were of small size. One genus (*Pteraspis*), apparently the oldest of the whole, belongs, however, to a tribe of mailed fishes allied to some of those of the old red sandstone. In both cases the groups of fishes representing the first known appearance of the vertebrates were allied to tribes of somewhat high organization in that class; and they asserted their claims to dominancy by being predaceous and carnivorous creatures, which must have rendered themselves formidable to their invertebrate contemporaries. Coprolites, or fossil masses of excrement, which are found with them, indicate that they chased and devoured orthoceratites and sea-snails of various kinds, and snapped *Lingulæ* and crinoids from their stalks; and we can well imagine that these creatures, when once introduced, found themselves in rich pasture and increased accordingly. Space prevents us from following further our pictures of the animal life of the great Silurian era, the monuments of which were first discovered by two of England's greatest geologists, Murchison and Sedgwick. How imperfect such a notice must be, may be learned from the fact that Dr. Bigsby, in his "Thesaurus Siluricus," in 1868, catalogues 8,897 Silurian species, of which only 972 are known in the Primordial.

Our illustration, carefully studied, may do more to present to the reader the teeming swarms of the

Silurian seas than our word-picture, and it includes many animal forms not mentioned above, more especially the curved and nautilus-like cuttle-fishes, those singular molluscous swimmers by fin or float known to zoologists as violet-snails, winged-snails or pteropods, and carinarias; and which, under various forms, have existed from the Silurian to the present time. The old *Lingulæ* are also there as well as in the Primordial, while the fishes and the land vegetation belong, as far as we yet know, exclusively to the Upper Silurian, and point forward to the succeeding Devonian. We know as yet no Silurian animal that lived on the land or breathed air. But our knowledge of land plants, though very meagre, is important. Without regarding such obscure and uncertain forms as the *Eophyton* of Sweden, Hooker, Page, and Barrande have noticed, in the Upper Silurian, plants allied to the Lycopods or club-mosses. I have found in the same deposits another group of plants allied to Lycopods and pill-worts (*Psilophyton*), and fragments of wood representing the curious and primitive type of pine-like trees known as *Prototaxites*. These are probably only a small instalment of Silurian land plants, such as a voyager might find floating in the sea on his approach to some unknown shore, which had not yet risen above his horizon. Time and careful search will, no doubt, add largely to our knowledge.

In the Silurian, as in the Cambrian, the headquarters of animal life were in the sea. Perhaps there

was no animal life on the land ; but here our knowledge may be at fault. It is, however, interesting to observe the continued operation of the creative fiat, "Let the waters swarm with swarmer," which, beginning to be obeyed in the Eozoic age, passes down through all the periods of geological time to the "moving things innumerable" of the modern ocean. Can we infer anything further as to the laws of creation from these Silurian multitudes of living things ? One thing we can see plainly, that the life of the Silurian is closely related to that of the Cambrian. The same generic and ordinal forms are continued. Even some species may be identical. Does this indicate direct genetic connection, or only like conditions in the external world correlated with likeness in the organic world ? It indicates both. First, it is in the highest degree probable that many of the animals of the Lower Silurian are descendants of those of the Cambrian. Sometimes these descendants may be absolutely unchanged. Sometimes they may appear as distinct varieties. Sometimes they may have been regarded as distinct though allied species. The continuance in this manner of allied forms of life is necessarily related to the continuance of somewhat similar conditions of existence, while changes in type imply changed external conditions. But is this all ? I think not ; for there are forms of life in the Silurian which cannot be traced to the Cambrian, and which relate to new and even prospective conditions, which the unaided powers of the animals of the earlier period could

not have provided for. These new forms require the intervention of a higher power, capable of correlating the physical and organic conditions of one period with those of succeeding periods. Whatever powers may be attributed to natural selection or to any other conceivable cause of merely genetic evolution, surely prophetic gifts cannot be claimed for it; and the life of all these geological periods is full of mute prophecies to be read only in the light of subsequent fulfilments.

The fishes of the Upper Silurian are such a prophecy. They can claim no parentage in the older rocks, and they appear at once as kings of their class. With reference to the Silurian itself, they are of little consequence; and in the midst of its gigantic forms of invertebrate life they seem almost misplaced. But they predict the coming Devonian, and that long and varied reign of vertebrate life which culminates in man himself. No such prophetic ideas are represented by the giant crustaceans and cuttle-fishes and swarming graptolites. They had already attained their maximum, and were destined to a speedy and final grave in the Silurian, or to be perpetuated only in decaying families whose poverty is rendered more conspicuous by the contrast with the better days gone by. The law of creation provided for new types, and at once for the elevation and degradation of them when introduced; and all this with reference to the physical conditions not of the present only but of the future. Such facts, which cannot be ignored save by the wilfully blind, are beyond the reach of any merely material philosophy.

The little that we know of Silurian plants is as eloquent of plan and creation as that which we can learn of animals. I saw not long ago a series of genealogies in geological time reduced to tabular form by that ingenious but imaginative physiologist, Haeckel. In one of these appeared the imaginary derivation of the higher plants from Algæ or sea-weeds. Nothing could more curiously contradict actual facts. Algæ were apparently in the Silurian neither more nor less elevated than in the modern seas, and those forms of vegetable life which may seem to bridge over the space between them and the land plants in the modern period, are wanting in the older geological periods, while land plants seem to start at once into being in the guise of club-mosses, a group by no means of low standing. Our oldest land plants thus represent one of the highest types of that cryptogamous series to which they belong, and moreover are better developed examples of that type than those now existing. We may say, if we please, that all the connecting links have been lost; but this is begging the whole question, since nothing but the existence of such links could render the hypothesis of derivation possible. Further, the occurrence of any number of successive yet distinct species would not be the kind of chain required, or rather would not be a chain at all.

Yet in some respects development is obvious in creation. Old forms of life are often embryonic, or resemble the young of modern animals, but enlarged and exaggerated, as if they had overgrown themselves

and had prematurely become adult. Old forms are often generalized, or less specific in their adaptations than those of modern times. There is less division of labour among them. Old forms sometimes not only rise to the higher places in their groups, but usurp attributes which in later times are restricted to their betters. Old forms are often gigantic in size in comparison with their modern successors, which, if they could look back on their predecessors, might say, "There were giants in those days." Some old forms have gone onward in successive stages of elevation by a regular and constant gradation. Others have remained as they were through all the ages. Some have no equals in their groups in modern days. All these things speak of order, but of order along with development, and this development not evolution; unless by this term we understand the emergence into material facts of the plans of the creative mind. These plans we may hope in some degree to understand, though we may not be able to comprehend the mode of action of creative power any more than the mode in which our own thought and will act upon the machinery of our own nerves. Still, the power is not the less real, that we are ignorant of its mode of operation. The wind bloweth whither it listeth, and we feel its strength, though we may not be able to calculate the wind of to-morrow or the winds of last year. So is the Spirit of God when it breathes into animals the breath of life, or the Almighty word when it says, "Let the waters bring forth."

CHAPTER V.

THE DEVONIAN AGE.

PARADOXICAL as it may appear, this period of geological history has been held as of little account, and has even been by some geologists regarded as scarcely a distinct age, just because it was one of the most striking and important of the whole. The Devonian was an age of change and transition, in both physical and organic existence; and an age which introduced, in the Northern hemisphere at least, more varied conditions of land and water and climate than had previously existed. Hence, over large areas of our continents, its deposits are irregular and locally diverse; and the duration and importance of the period are to be measured rather by the changes and alterations of previous formations, and the ejection of masses of molten rock from beneath, than by a series of fossiliferous deposits. Nevertheless, in some regions in North America and Eastern Europe, the formations of this era are of vast extent and volume, those of North America being estimated at the enormous thickness of 15,000 feet, while they are spread over areas of almost continental breadth.

At the close of the Upper Silurian, the vast continental plateaus of the northern hemisphere were almost wholly submerged. No previous marine lime-

stone spreads more widely than that of the Upper Silurian, and in no previous period have we much less evidence of the existence of dry land ; yet before the end of the period we observe, in a few fragments of land plants scattered here and there in the marine limestones—evidence that islands rose amid the waste of waters. As it is said that the sailors of Columbus saw the first indications of the still unseen Western Continent in drift canes, and fragments of trees floating in mid ocean, so the voyager through the Silurian seas finds his approach to the verdant shores of the Devonian presaged by a few drift plants borne from shores yet below the horizon. The small remains of land in the Upper Silurian were apparently limited to certain clusters of islands in the north-eastern part of America and north-western part of Europe, with perhaps some in the intervening Atlantic. On these limited surfaces grew the first land plants certainly known to us—herbs and trees allied to the modern club-mosses, and perhaps forests of trees allied to the pines, though of humbler type ; and this wide Upper Silurian sea, with archipelagos of wooded islands, may have continued for a long time. But with the beginning of the Devonian, indications of an unstable condition of the earth's crust began to develop themselves. New lands were upheaved ; great shallow, muddy, and sandy flats were deposited around them ; the domains of corals and sea-weeds were contracted ; and on banks, and in shallows and estuaries, there swarmed shoals of fishes of many species, and some of

them of most remarkable organization. On the margins of these waters stretched vast swamps, covered with a rank vegetation.

But the period was one of powerful igneous activity. Volcanoes poured out their molten rocks over sea and land, and injected huge dykes of trap into the newly-formed beds. The land was shaken with earthquake throes, and was subject to many upheavals and subsidences. Violent waves desolated the coasts, throwing sand and gravel over the flats, and tearing up newly-deposited beds; and poisonous exhalations, or sudden changes of level, often proved fatal to immense shoals of fishes. This was the time of the Lower Devonian, and it is marked, both in the old world and the new, by extensive deposits of sandstones and conglomerates.

But the changes going on at the surface were only symptomatic of those occurring beneath. The immense accumulations of Silurian sediment had by this time so overweighted certain portions of the crust, that great quantities of aqueous sediment had been pressed downward into the heated bowels of the earth, and were undergoing, under an enormous weight of superincumbent material, a process of baking and semi-fusion. This process was of course extremely active along the margins of the old Silurian plateaus, and led to great elevation of land, while in the more central parts of the plateaus the oceanic conditions still continued; and in the Middle Devonian, in America at least, one of the most remarkable and

interesting coral limestones in the world—the corniferous limestone—was deposited. In process of time, however, these clear waters became shallow, and were invaded by muddy sediments; and in the Upper Devonian the swampy flats and muddy shallows return in full force, and in some degree anticipate the still greater areas of this kind which existed in the succeeding Coal formation.

Such is a brief sketch of the Devonian, or, as it may be better called in America, from the vast development of its beds on the south side of Lake Erie, the *Erian* formation. In America the marine beds of the Devonian were deposited on the same great continental plateau which supported the seas of the Upper and Lower Silurian, and the beds were thicker towards the east and thinned towards the west, as in the case of the older series. But in the Devonian there was much land in the north-east of America; and on the eastern margin of this land, as in Gaspé and New Brunswick, the deposits throughout the whole period were sandstones and shales, without the great coral limestones of the central plateau. Something of the same kind occurred in Europe, where, however, the area of Devonian sea was smaller. There the fossiliferous limestones of the Middle Devonian in Devon, in the Eifel district, in France and in Russia, represent the great corniferous limestone of America; while the sandstones of South Wales, of Ireland, and of Scotland, resemble the local conditions of Gaspé and New Brunswick, and

belonged to a similar area in the north-west of Europe, in which shallow water and land conditions prevailed during the whole of the Devonian, and which was perhaps connected with the corresponding region in Eastern America by a North Atlantic archipelago, now submerged. This whole subject is so important to the knowledge of the Devonian, and of geology in general, that I may be pardoned for introducing it here in a tabular form, taking the European series from Etheridge's excellent and exhaustive paper in the "Journal of the Geological Society."

DEVONIAN OR ERIAN.

DIVISIONS.	CENTRAL AREAS.		
	Devon.	Rhen. Prussia.	New York.
Upper	Pilton group :— Brown calcareous shales, brown and yellow sandstone. Land plants and marine shells.	Clymenia, Cypridina, etc. Shales, limestones, and sandstones. Plants and marine shells.	Chemung and Portage. Sandstones and shales. Plants and marine shells.
Middle	Ifracombe group :— Grey and red sandstones and flags, calcareous slates and limestones, with corals, etc.	Eifel limestone, Calceola shales, etc. Corals, shells, etc.	Hamilton shales, and Corniferous or cherty limestone. Many corals and shells, also plants.
Lower	Lynton group :— Red and purple sandstones. Marine shells, etc.	Coblentz and Wisenbach shales, Rhenish greywacke, Spirifer sandstone. Marine shells.	Schoharie and Caudagalli grits. Oriskany sandstones. Marine shells.

DIVISIONS.	MARGINAL AREAS.		
	Scotland.	Ireland.	Gaspé and New Brunswick.
Upper	Yellow and red sandstones. Fishes and plants.	Yellow and red sandstones, etc. Plants, fishes, etc.	Red and grey sandstones, grits and shales, and conglomerates of Gaspé and Mispeck. Plants.
Middle	Red shales and sandstones, and conglomerates. Caithness flags. Fishes and plants.	Grits and sandstones of Dingle.	Grey and Red sandstones, and grey and dark shales. Gaspé and St. John. Many plants and fishes.
Lower	Flagstones, shales and conglomerates. Fishes and plants.	Glengariff grits, etc.	Sandstone and conglomerate. Plants and fishes. Gaspé and St. John.

A glance at this table suffices to show that when we read Hugh Miller's graphic descriptions of the Old Red Sandstone of Scotland, with its numerous and wonderful fishes, we have before us a formation altogether distinct from that of Devonshire or the Eifel. But the one represents the shallow, and the other the deeper seas of the same period. We learn this by careful tracing of the beds to their junction with corresponding series, and by the occasional occurrence of the characteristic fishes of the Scottish strata in the English and German beds. In like manner a geologist who explores the Gaspé sandstones or the New Brunswick shales has under his

consideration a group of beds very dissimilar from that which he would have to study on the shores of Lake Erie. But here again identity of relations to the Silurian below and the carboniferous above, shows the contemporaneousness of the beds, and this is confirmed by the occurrence in both series of some of the same plants and shells and fishes.

It will further be observed that it is in the middle that the greatest difference occurs. Sand and mud and pebble-banks were almost universal over our two great continental plateaus in the Older and Newer Devonian. But in the Middle there were in some places deeper waters with coral reefs, in others shallow flats and swamps rich in vegetation. Herein we see the greater variety and richness of the Devonian. Had we lived in that age, we should not have seen great continents like those that now exist, but we could have roamed over lovely islands with breezy hills and dense lowland jungles, and we could have sailed over blue coral seas, glowing below with all the fanciful forms and brilliant colours of polyp life, and filled with active and beautiful fishes. Especially did all these conditions culminate in the Middle Devonian, when what are now the continental areas of the northern hemisphere must have much resembled the present insular and oceanic reigons of the South Pacific.

Out of the rich and varied life of the Devonian I may select for illustration its corals, its crustaceans, its fishes, its plants, and its insects.

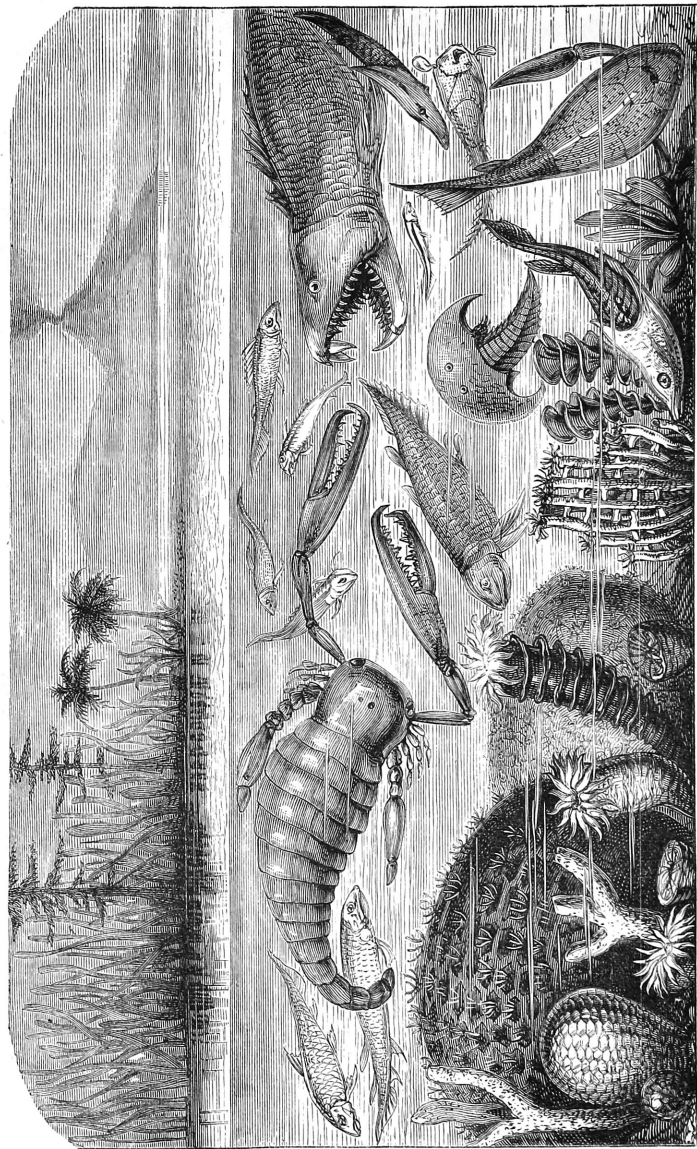


Fig. 11.—CORALS, FISHES, AND CRUSTACEANS OF THE DEVONIAN.
 In the foreground are Corals of the genera *Favosites*, *Michelinia*, *Phillipsastrea*, *Zaphrentis*, *Blotrophylthum*, and *Syringopora*, and the seaweed *Spirophyton*; also Fishes of the genera *Cephalaspis* and *Pterichthys*. Above are *Pterygotus* and *Denticthys*, with Fishes of the genera *Diplacanthus*, *Osteolepis*, *Holoptychius*, *Pteraspis*, *Coccosteus*, etc. The distant land has *Leplidodendra*, *Pines*, and *Tree-ferns*.

The central limestones of the Devonian may be regarded as the head-quarters of the peculiar types of coral characteristic of the Palæozoic age. Here they were not only vastly numerous, but present some of their grandest and also their most peculiar forms. Edwards and Haime, in their "Monograph of British Fossil Corals," in 1854, enumerate one hundred and fifty well-ascertained species, and the number has since been largely increased; I have no doubt that my friend Dr. Bigsby, in his forthcoming "Thesaurus Devonicus," will more than double it. In the Devonian limestones of England, as for instance at Torquay, the specimens, though abundant and well preserved as to their internal structure, are too firmly imbedded in the rock to show their external forms. In the Devonian of the continent of Europe much finer specimens occur; but, perhaps, in no part of the world is there so clear an exhibition of them as in the Devonian limestones of the United States and Canada. Sir Charles Lyell thus expresses his admiration of the exposure of these corals, which he saw at the falls of the Ohio, near Louisville. He says, "Although the water was not at its lowest, I saw a grand display of what may be termed an ancient coral-reef, formed by zoophytes which flourished in a sea of earlier date than the Carboniferous period. The ledges of horizontal limestone, over which the water flows, belong to the Devonian group, and the softer parts of the stone have decomposed and wasted away, so that the

harder calcareous corals stand out in relief. Many branches of these zoophytes project from their erect stems precisely as if they were living. Among other species I observed large masses, not less than five feet in diameter, of *Favosites Gothlandica*, with its beautiful honeycomb structure well displayed. There was also the cup-shaped *Cyathophyllum*, and the delicate network of *Fenestella*, and that elegant and well-known European species of fossil, the chain coral, *Catenipora escharoides*, with a profusion of others which it would be tedious to all but the geologist to enumerate. Although hundreds of fine specimens have been detached from these rocks to enrich the museums of Europe and America, another crop is constantly working its way out under the action of the stream, and of the sun and rain in the warm season when the channel is laid dry.* These limestones have been estimated to extend, as an almost continuous coral reef, over the enormous area of five hundred thousand square miles of the now dry and inland surface of the great American continental plateau. The limestones described by Sir Charles are known in the Western States as the "Cliff limestone." In the State of New York and in Western Canada the "Corniferous limestone," so called from the masses of hornstone, like the flint of the English chalk, contained in it, presents still more remarkable features. The corals which it contains have been

* "Travels in North America," second series.

replaced by the siliceous or flinty matter in such a manner that, when the surrounding limestone weathers away, they remain projecting in relief in all the beauty of their original forms. Not only so, but on the surface of the country they remain as hard siliceous stones, and may be found in ploughing the soil and in stone fences and roadside heaps, so that tons of them could often be collected over a very limited space. When only partly disengaged from the matrix, the process may be completed by immersing them in a dilute acid. The beauty of these specimens when thus prepared is very great—not at all inferior to that of modern corals, which they often much resemble in general form, though differing in details of structure. One of the most common forms is that of the *Favosites*, or honeycomb coral, presenting regular hexagonal cells with transverse floors or tabulæ. Of these there are several species, usually flat or massive in form; but one species, *F. polymorpha*, branches out like the modern stag-horn corals. Another curious form, *Michelina*, looks exactly like a mass of the papery cells of the great American hornet in a petrified state, and the convex floors simulate the covers of the cells, so that it is quite common to find them called fossil wasps' nests. Some of the largest belong to the genus *Philipsastrea* or *Smithia*, which Hugh Miller has immortalized by comparing its crowded stars, with confluent rays, to the once-popular calico pattern known as "Lane's net"—a singular instance of the

accidental concurrence of a natural and artificial design. Another very common type is that of the conical *Zaphrentis*, with a deep cut at top to lodge the body of the animal, whose radiating chambers are faithfully represented by its delicate lamellæ. Perhaps the most delicate of the whole is the *Syringopora*, with its cylindrical worm-like pipes bound together by transverse processes, and which sometimes can be dissolved out in all its fragile perfection by the action of an acid on a mass of Corniferous limestone filled with these corals in a silicified state.

These Devonian corals, like those of the Silurian, belong to the great extinct groups of Tabulate and Rugose corals; groups which present, on the one hand, points of resemblance to the ordinary coral animals of the modern seas, and, on the other, to those somewhat exceptional corals, the Millepores, which are produced by another kind of polyp, the Hydroids. Some of them obviously combine properties belonging to both, as, for example, the radiating partitions with the arrangement of the parts in multiples of four, the horizontal floors, and the external solid wall; and this fact countenances the conclusion that in these old corals we have a group of high and complex organization, combining properties now divided between two great groups of animals, neither of them probably, either in their stony skeletons or the soft parts of the animal, of as high organization as their Palæozoic predecessors. This sort of disintegration of composite types, or dissolution of old partnerships, seems

to have been no unusual occurrence in the history of life.*

If the Devonian witnessed the culmination of the Palæozoic corals, its later stages saw the final decadence of the great dynasty of the Trilobites. Of these creatures there are in the Devonian some large and ornate species, remarkable for their spines and tubercles; as if in this, the latter day of their dominion, they had fallen into habits of luxurious decoration unknown to their sterner predecessors, and at the same time had found it necessary to surround their now disputed privileges with new safeguards of defensive armour. Not improbably the decadence of the Trilobites may have been connected with the introduction of the numerous and formidable fishes of the period.

But while the venerable race of the Trilobites was preparing to fight its last and unsuccessful battle, another and scarcely less ancient tribe of crustaceans, the Eurypterids, already strong in the Silurian, was armed with new and formidable powers. The *Pterygotus anglicus*, which should have been named *scoticus*, since its head-quarters are in Scotland, was in point of size the greatest of known crustaceans, recent or fossil. According to Mr. Henry Woodward, who has published an admirable description and figures of the creature in the Palæontographical

* Verril has suggested that the Tabulata may be divided into two groups, one referable to Actinoids, the other to Hydroids.

Society's Memoirs, it must have been six feet in length, and nearly two feet in breadth. Its antennæ were, unlike the harmless feelers of modern crustacea, armed with powerful claws. Two great eyes stood in the front of the head, and two smaller ones on the top. It had four pairs of great serrated jaws, the largest as wide as a man's hand. At the sides were a pair of powerful paddles, capable of urging it swiftly through the water as it pursued its prey; and when attacked by any predaceous fish, it could strike the water with its broad tail, terminated by a great flat "telson," and retreat backward with the rapidity of an arrow. Woodward says it must have been the "shark of the Devonian seas;" rather, it was the great champion of the more ancient family of the lobsters, set to arrest, if possible, the encroachments of the coming sharks.

The Trilobites and Eurypterids constitute a hard case for the derivationists. Unlike those Melchisedeks, the fishes of the Silurian, which are without father or mother, the Devonian crustaceans may boast of their descent, but they have no descendants. No distinct link connects them with any modern crustaceans except the Limuli, or horse-shoe crabs; and here the connection is most puzzling, for while there seems some intelligible resemblance between the adult Eurypterids and the horse-shoe, or king-crabs, the latter, in their younger state, rather resemble Trilobites, as Dr. Packard has recently shown. Thus the two great tribes of Eurypterids and Trilobites

have united in the small modern group of king-crabs, while on the other hand, there are points of resemblance, as already stated, between Trilobites and Isopods, and the king-crabs had already begun to exist, since one species is now known in the Upper Silurian. So puzzling are these various relationships, that one naturalist of the derivationist school has recently attempted to solve the difficulty by suggesting that the Trilobites are allied to the spiders! Thus nature sports with our theories, showing us in some cases, as in the corals and fishes, partnerships split up into individuals, and in others distinct lines of being converging and becoming lost in one slender thread. Barrande, the great palæontologist of Bohemia, has recently, in an elaborate memoir on the Trilobites, traced these and other points through all their structures and their whole succession in geological time thereby elaborating a most powerful inductive argument against the theory of evolution, and concluding that, so far from the history of these creatures favouring such a theory, it seems as if expressly contrived to exclude its possibility.

But, while the gigantic Eurypterids and ornate Trilobites of the Devonian were rapidly approaching their end, a few despised little crustaceans,—represented by the *Amphipeltis* of New Brunswick and *Kampecaris* of Scotland,—were obscurely laying the foundation of a new line of beings, that of the Stomatopods, destined to culminate in the Squillas and their allies, which, however different in structure, are

practically the Eurypterids of the modern ocean. So change the dynasties of men and animals.

“Thou takest away their breath, they die,
They return to their dust ;
Thou sendest forth Thy Spirit,
They are created ;
Thou renewest the form of the earth.”

The reign of fishes began in the Upper Silurian, for in the rocks of this age, more especially in England, several species have been found. They occur, however, only in the newer beds of this formation, and are not of large size, nor very abundant. It is to be observed that, in so far as the fragments discovered can be interpreted, they indicate the existence already of two distinct types of fishes, the Ganoids, or gar-fishes, protected with bony plates and scales, and the Placoids, or shark-like fishes ; and that in the existing world these fishes are regarded as occupying a high place in their class. Further, these two groups of fishes are those which throughout a large portion of geological time continue to prevail to the exclusion of other types, the ordinary bony fishes having been introduced only in comparatively recent periods. With the Devonian, however, there comes a vast increase to the finny armies ; and so characteristic are these that the Devonian has been called the age of fishes *par excellence*, and we must try, with the help of our illustration, to paint these old inhabitants of the waters as distinctly as we can. Among the

most ancient and curious of these fishes are those singular forms covered with broad plates, of which the *Pteraspis* of the Upper Silurian is the herald, and which are represented in the Lower Devonian by several distinct genera. Of these, one of the most curious is the *Cephalaspis*, or buckler-head, distinguished by its broad flat head, rounded in front and prolonged at the sides into two great spines, which project far beyond the sides of the comparatively slender body. This fish, it may be mentioned, is the type of a family highly characteristic of the Lower Devonian, as well as of the Upper Silurian, and all of which are provided with large plate-like cephalic coverings, sometimes with a long snout in front, and, in so far as is known, a comparatively weak body and tail. They were all probably ground-living creatures, feeding on worms and shell-fishes, and "rooting" for these in the mud, or burrowing therein for their safety. In these respects they have a most curious analogy to the Trilobites, which in habits they must have greatly resembled, though belonging by their structure to an entirely different and much higher class. So close is this resemblance, that their head-shields used to be mistaken for those of Trilobites. The case is one of those curious analogies which often occur in nature, and which must always be distinguished from the true affinities which rest on structural resemblances. Another group of small fishes, likewise cuirassed in bony armour of plates, may be represented by the

Pterichthys, with its two strong bony fins at the sides, which may have served for swimming, but probably also for defence, and for creeping on or shovelling up the mud at the bottom of the sea. But, besides the Ganoids which were armed in plated cuirasses, there were others, active and voracious, clad in shining enamelled scales, like the bony pikes of the American rivers and the *Polypterus* of the Nile. Some of these, like the *Diplacanthus*, or "double-spine," were of small size, and chiefly remarkable for their sharp defensive bony spines. Others, like *Holoptychius* (wrinkled-scale) and *Osteolepis* (bone-scale), were strongly built, and sometimes of great size. One Russian species of *Asterolepis* (star-scale) is supposed to have been twenty feet in length, and furnished with strong and trenchant teeth in two rows. These great fishes afford a good reason for the spines and armour-plates of the contemporary trilobites and smaller fishes. Just as man has been endeavouring to invent armour impenetrable to shot, for soldiers and for ships, and, on the other hand, shot and shells that can penetrate any armour, so nature has always presented the spectacle of the most perfect defensive apparatus matched with the most perfect weapons for destruction. In the class of fishes, no age of the world is more eminent in these respects than the Devonian.* In addition

* Many of these were discovered and successfully displayed and described by Hugh Miller, and are graphically portrayed in his celebrated work on the "Old Red Sandstone," published in 1841.

to these fishes, there were others, represented principally by their strong bony spines, which must have been allied to some of the families of modern sharks, most of them, however, probably to that comparatively harmless tribe which, furnished with flat teeth, prey upon shell-fishes. There are other fishes difficult to place in our systems of classification; and among these an eminent example is the huge *Dinichthys* of Newberry, from the Hamilton group of Ohio. The head of this creature is more than three feet long and eighteen inches broad, with the bones extraordinarily strong and massive. In the upper jaw, in addition to strong teeth, there were in front two huge sabre-shaped tusks or incisors, each nearly a foot long; and corresponding to these in the massive lower jaw were two closely joined conical tusks, fitting between those of the upper jaw. No other fish presents so frightful an apparatus for destruction; and if, as is probable, this was attached to a powerful body, perhaps thirty feet in length, and capable of rapid motion through the water, we cannot imagine any creature so strong or so well armed as to cope with the mighty *Dinichthys*.

The difference between the fishes of the Devonian and those of the modern seas is well marked by the fact that, while the ordinary bony fishes now amount to probably 9,000 species, and the ganoid fishes to less than thirty, the finny tribes of the Devonian are predominantly ganoids, and none of the ordinary type are known. To what is this related, with reference

to conditions of existence? Two explanations, different yet mutually connected, may be suggested. One is that armour was especially useful in the Devonian as a means of defence from the larger predaceous species, and the gigantic crustaceans of the period. That this was the case may be inferred from the conditions of existence of some modern ganoids. The common bony pike of Canada (*Lepidosteus*), frequenting shallow and stagnant waters, seems to be especially exposed to injury from its enemies. Consequently, while it is rare to find an ordinary fish showing any traces of wounds, a large proportion of the specimens of the bony pike which I have examined have scars on their scales, indicating injuries which they have experienced, and which possibly, to fishes not so well armed, might have proved fatal. Again, in the modern *Amia*, or mud-fish, in the bony pike and *Polypterus*, there is an extremely large air-bladder, amply supplied with blood-vessels, and even divided into cells or chambers, and communicating with the mouth by an "air-duct." This organ is unquestionably in function a lung, and enables the animal to dispense in some degree with the use of its gills, which of course depend for their supply of vital air on the small quantity of oxygen dissolved in the water. Hence, by the power of partially breathing air, these fishes can live in stagnant and badly aerated waters, where other fishes would perish. In the case of the *Amia*, the grunting noises which it utters, its habit of frequenting the muddy creeks of swamps,

and its possession of gill-cleaners, correspond with this view. It is possible that the Devonian fishes possessed this semi-reptilian respiration; and if so, they would be better adapted than other fishes to live in water contaminated with organic matter in a state of decay, or in waters rich in carbonic acid or deficient in oxygen. Possibly the palæozoic waters, as well as the palæozoic atmosphere, were less rich in pure oxygen than those of the present world; and it is certain that, in many of the beds in which the smaller Devonian fishes abound, there was so much decaying vegetable matter as to make it probable that the water was unfit for the ordinary fishes. Thus, though at first sight the possession of external armour and means to respire air, in the case of these peculiar fishes, may seem to have no direct connection with each other, their obvious correlation in some modern ganoids may have had its parallel on a more extensive scale among their ancient relatives. Just as the modern gar-fish, by virtue of its lungs, can live in stagnant shallows and hunt frogs, but on that account needs strong armour to defend it against the foes that assail it in such places; so in the Devonian the capacity to inhabit unaërated water and defensive plates and scales may have been alike necessary, especially to the feebler tribes of fishes. We shall find that in the succeeding carboniferous period there is equally good evidence of this.

We have reserved little space for the Devonian plants and insects; but we may notice both in a walk

through a Devonian forest, in which we may include the vegetation of the several subordinate periods into which this great era was divisible. The Devonian woods were probably, like those of the succeeding carboniferous period, dense and dark, composed of but few species of plants, and these somewhat monotonous in appearance, and spreading out into broad swampy jungles, encroaching on the shallow bays and estuaries. Landing on one of these flats, we may first cast our eyes over a wide expanse, covered with what at a distance we might regard as reeds or rushes. But on a near approach they appear very different; rising in slender, graceful stems, they fork again and again, and their thin branches are sparsely covered with minute needle-like leaves, while the young shoots curl over in graceful tresses, and the older are covered with little oval fruits, or spore-cases; for these plants are cryptogamous, or flowerless. This singular vegetation stretches for miles along the muddy flats, and rises to a height of two or three feet from a knotted mass of cylindrical roots or root-stocks, twining like snakes through and over the soil. This plant may, according as we are influenced by its fruit or structure, be regarded as allied to the modern club-mosses or the modern pill-worts. It is *Psilophyton*, in every country one of the most characteristic plants of the period, though, when imperfectly preserved, often relegated by careless and unskilled observers to the all-engulfing group of fucoids. A little further inland we see a grove of graceful trees, forking like *Psi-*

lophyton, but of grander dimensions, and with the branches covered with linear leaves, and sometimes terminated by cones. These are *Lepidodendra*, gigan-

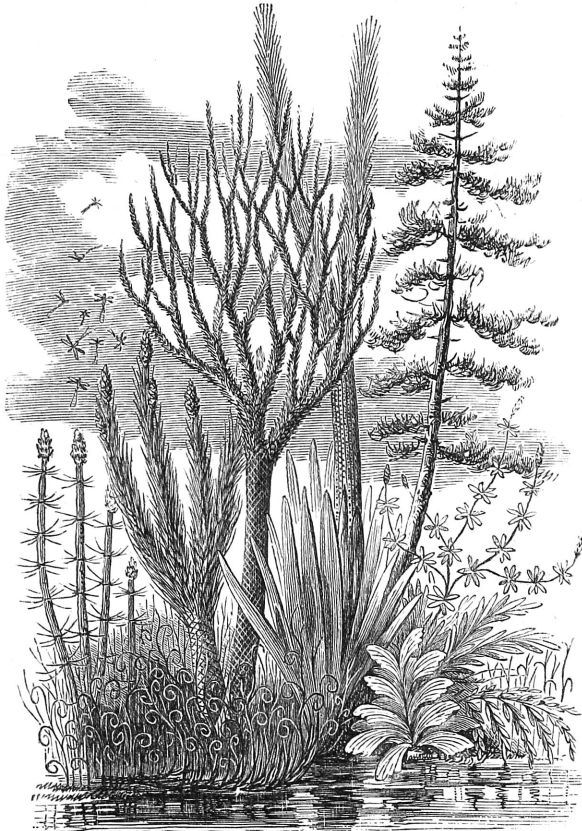


Fig. 12.—VEGETATION OF THE DEVONIAN.

To the left are *Calamites*; next to these, *Leptophleum*; in the centre are *Lepidodendron*, *Sigillaria*, and a Pine. Below are *Psilophyton*, *Cordaites*, Ferns, and *Asterophyllites*.

tic club-mosses, which were developed to still greater dimensions in the coal period. Near these we may see a still more curious tree, more erect in its growth, with rounded and somewhat rigid leaves and cones of different form, and with huge cable-like roots, penetrating the mud, and pitted with the marks of long rootlets. This is *Cyclostigma*, a plant near to the *Lepidodendron*, but distinct, and peculiar to the Devonian. Some of its species attain to the dimensions of considerable trees; others are small and shrubby. Another small tree, somewhat like the others, but with very long shaggy leaves, and its bark curiously marked with regular diamond-shaped scars, is the *Leptophleum*. All these plants are probably allied to our modern club-mosses, which are, however, also represented by some low and creeping species cleaving to the ground. A little further, and we reach a dense clump of *Sigillaria*, with tall sparsely forking stems, and ribbed with ridges holding rows of leaf-scars—a group of plants which we shall have further occasion to notice in the coal formation; and here is an extensive jungle of *Calamites*, gigantic and overgrown mares'-tails, allies of the modern equisetums.

Amidst these trees, every open glade is filled with delicate ferns of marvellous grace and beauty; and here and there a tree-fern rears its head, crowned with its spreading and graceful leaves, and its trunk clad with a shaggy mass of aerial roots—an old botanical device, used in these ancient times, as well

as now, to strengthen and protect the stems of trees not fitted for lateral expansion. Beyond this mass of vegetation, and rising on the slopes of the distant hills, we see great trees that look like pines. We cannot approach them more nearly; but here on the margin of a creek we see some drift-trunks, that have doubtless been carried down by a land flood. One of them is certainly a pine, in form and structure of its wood very like those now living in the southern hemisphere; it is a *Dadoxylon*. Another is different, its sides rough and gnarled, and marked with huge irregular ridges; its wood loose, porous, and stringy, more like the bark of modern pines, yet having rings of growth and a true bark of its own, and sending forth large branches and roots. It is the strange and mysterious *Prototaxites*, one of the wonders of the Devonian land, and whose leaves and fruits would be worth their weight in gold in our museums, could we only procure them. A solitary fragment further indicates that in the yet unpenetrated solitudes of the Devonian forests there may be other trees more like our ordinary familiar friends of the modern woods; but of these we know as yet but little. What inhabitants have these forests? All that we yet know are a few large insects, relatives of our modern May-flies, flitting with broad veined wings over the stagnant waters in which their worm-like larvæ dwell, and one species at least assuming one of the properties of the grasshopper tribe, and enlivening the otherwise silent groves with a cricket-like chirp, the oldest

music of living things that geology as yet reveals to us ; and this, not by the hearing of the sound itself, but by the poor remains of the instrument attached to a remnant of a wing from the Devonian shales of New Brunswick.

A remarkable illustration of the abundance of certain plants in the Devonian, and also of the slow and gradual accumulation of some of its beds, is furnished by layers of fossil spore-cases, or the minute sacs which contain the microscopic germs of club-mosses and similar plants. In the American forests, in spring, the yellow pollen-grains of spruces and pines sometimes drift away in such quantities in the breeze that they fall in dense showers, popularly called showers of sulphur ; and this vegetable sulphur, falling in lakes and ponds, is drifted to the shore in great sheets and swathes. The same thing appears to have occurred in the Devonian, not with the pollen of flowering plants, but with the similar light spores and spore-cases of species of *Lepidodendron* and allied trees. In a bed of shale, at Kettle Point, Lake Huron, from 12 to 14 feet thick, not only are the surfaces of the beds dotted over with minute round spore-cases, but, on making a section for the microscope, the substance of each layer is seen to be filled with them ; and still more minute bodies, probably the escaped spores, are seen to fill up their interstices. The quantity of these minute bodies is so great that the shale is combustible, and burns with much flame. A bed of this nature must have been formed in

shallow and still water, on the margin of an extensive jungle or forest; and as the spore-cases are similar to those of the *Lepidodendra* of the coal-measures, the trees were probably of this kind. Year after year, as the spores became ripe, they were wafted away, and fell in vast quantities into the water, to be mixed with the fine mud there accumulating. When we come to the coal period, we shall see that such beds of spore-cases occur there also, and that they have even been supposed to be mainly instrumental in the accumulation of certain beds of coal. Their importance in this respect may have been exaggerated, but the fact of their occurrence in immense quantities in certain coals and shales is indisputable.

This is but a slender sketch of the Devonian forests; but we shall find many of the same forms of plants in the carboniferous period which succeeds. With one thought we may close. We are prone to ask for reasons and uses for things, but sometimes we cannot be satisfied. Of what use were the Devonian forests? They did not, like those of the coal formation, accumulate rich beds of coal for the use of man. Except possibly a few insects, we know no animals that subsisted on their produce, nor was there any rational being to admire their beauty. Their use, except as helping us in these last days to complete the order of the vegetable kingdom as it has existed in geological time, is a mystery. We can but fall back on that ascription of praise to Him "who liveth for ever and ever," on the part of the heavenly

elders who cast down their crowns before the throne, and say, "Thou art worthy, O Lord, to receive the glory, and the honour, and the might; because Thou didst create all things, and by reason of *Thy will* they are and were created."

CHAPTER VI.

THE CARBONIFEROUS AGE.

THAT age of the world's history which, from its richness in accumulations of vegetable matter destined to be converted into coal, has been named the Carboniferous, is in relation to living beings the most complete and noble of the Palæozoic periods. In it those varied arrangements of land and water which had been increasing in perfection in the previous periods, attained to their highest development. In it the forms of animal and plant life that had been becoming more numerous and varied from the Eozoic onward, culminated. The Permian which succeeded was but the decadence of the Carboniferous, preparatory to the introduction of a new order of things. Thus the Carboniferous was to the previous periods what the Modern is to the preceding Tertiary and Mesozoic ages—the summation and completion of them all, and the embodiment of their highest excellence. If the world's history had closed with the Carboniferous, a naturalist, knowing nothing further, would have been obliged to admit that it had already fulfilled all the promise of its earlier years. It is important to remember this, since we shall find ourselves entering on an entirely new scene in the Mesozoic

period, and since this character of the Carboniferous, as well as its varied conditions and products, may excuse us for dwelling on it a little longer than on the others. On the other hand, the immense economic importance of the coal formation, and the interesting points connected with it, have made the Carboniferous more familiar to general readers than most other geological periods, so that we may select points less common and well-known for illustration. Popular expositions of geology are, however, generally so one-sided and so distorted by the prevalent straining after effect, that the true aspect of this age is perhaps not much better known than that of others less frequently described.

Let us first consider the Carboniferous geography of the northern hemisphere; and in doing so we may begin with a fact concerning the preceding age. One of the most remarkable features of the Newer Devonian is the immense quantity of red rocks, particularly red sandstones, contained in it. Red sandstones, it is true, occur in older formations, but comparatively rarely; their great head-quarters, both in Europe and America, in so far as the Palæozoic is concerned, are in the Upper Devonian. Now red sandstone is an infallible mark of rapid deposition, and therefore of active physical change. If we examine the grains of sand in a red sandstone, we shall find that they are stained or coated, externally, with the peroxide of iron, or iron rust; and that this coating, with perhaps a portion of the same substance in the inter-

vening cement, is the cause of the colour. In finer sandstones and red clays the same condition exists, though less distinctly perceptible. Consequently, if red sands and clays are long abraded or scoured in water, or are subjected to any chemical agent capable of dissolving the iron, they cease to be red, and resume their natural grey or white colour. Now in nature, in addition to mechanical abrasion, there is a chemical cause most potent in bleaching red rocks, namely, the presence of vegetable or animal matter in a state of decay. Without entering into chemical details, we may content ourselves with the fact that organic matter decaying in contact with peroxide of iron tends to take oxygen from it, and then to dissolve it in the state of protoxide, while the oxygen set free aids the decay. Carrying this fact with us, we may next affirm that iron is so plentiful in the crust of the earth that nearly all sands and clays when first produced from the weathering of rocks are stained with it, and that when this weathering takes place in the air, the iron is always in the state of peroxide. More especially does this apply to the greater number of igneous or volcanic rocks, which nearly always weather brown or red. Now premising that the original condition of sediment is that of being reddened with iron, and that it may lose this by abrasion, or by the action of organic matter, it follows that when sand has been produced by decay of rocks in the air, and when it is rapidly washed into the sea and deposited there, red beds will result.

For instance, in the Bay of Fundy, whose rapid tides cut away the red rocks of its shores and deposit their materials quickly, red mud and sand constitute the modern deposit. On the other hand, when the red sand and mud are long washed about, their red matter may disappear; and when the deposition is slow and accompanied with the presence of organic matter, the red colour is not only removed, but is replaced by the dark tints due to carbon. Thus, in the Gulf of St. Lawrence, where red rocks similar to those of the Bay of Fundy are being more slowly wasted, and deposited in the presence of sea-weeds and other vegetable substances, the resulting sands and clays are white and grey or blackened in colour. An intermediate condition is sometimes observed, in which red beds are stained with grey spots and lines, where sea-weeds or land-plants have rested on them. I have specimens of Devonian red shale with the forms of fern leaves, the substance of which has entirely perished, traced most delicately upon them in greenish marks.

It follows from these facts that extensive and thick deposits of red beds evidence sub-aerial decay of rocks, followed by comparatively rapid deposition in water, and that such red rocks will usually contain few fossils, not only because of their rapid deposition, but because the few organic fragments deposited with them will probably have been destroyed by the chemical action of the superabundant oxide of iron, which, so to speak, "iron-moulds" them, just as stains of iron eat holes out of linen. Now when Sir

Roderick Murchison tells us of 10,000 feet in thickness of red iron-stained rocks in the old red sandstone of England, we can see in this the evidence of rapid aqueous deposition, going on for a very long time, and baring vast areas of former land surface. Consequently we have proof of changes of level and immense and rapid denudation—a conclusion further confirmed by the apparent unconformity of different members of the series to each other in some parts of the British Islands, the lower beds having been tilted up before the newer were deposited. Such was the state of affairs very generally at the close of the Devonian, and it appears to have been accompanied with some degree of subsidence of the land, succeeded by re-elevation at the beginning of the Carboniferous, when many and perhaps large islands and chains of islands were raised out of the sea, along whose margins there were extensive volcanic eruptions, evidenced by the dykes of trap traversing the Devonian, and the beds of old lava interstratified in the lower part of the Carboniferous, where also the occurrence of thick beds of conglomerate or pebble-rock indicates the tempestuous action of the sea.

But a careful study of the Lower Carboniferous beds, where their margins rest upon the islands of older rocks, shows great varieties in these old shores. In some places there were shingly beaches; in others, extensive sand-banks; in others, swampy flats clothed with vegetation, and sometimes bearing peaty beds, still preserved as small seams of coal. The bays and

creeks swarmed with fishes. A few sluggish reptiles crept along the muddy or sandy shores, and out seaward were great banks and reefs of coral and shells in the clear blue sea. The whole aspect of nature, taken in a general view, in the Older Carboniferous period, must have much resembled that at present seen among the islands of the southern hemisphere. And the plants and animals, though different, were more like those of the modern South Pacific than any others now living.

As the age wore on, the continents were slowly lifted out of the water, and the great continental plateaus were changed from coral seas into swampy flats or low uplands, studded in many places with shallow lakes, and penetrated with numerous creeks and sluggish streams. In the eastern continent these land surfaces prevailed extensively, more especially in the west; and in America they spread both eastward and westward from the Appalachian ridge, until only a long north and south Mediterranean, running parallel to the Rocky Mountains, remained of the former wide internal ocean. On this new and low land, comparable with the "Sylvas" of the South American continent, flourished the wondrous vegetation of the Coal period, and were introduced the new land animals, whose presence distinguishes the close of the Palæozoic.

After a vast lapse of time, in which only slow and gradual subsidence occurred, a more rapid settlement of the continental areas brought the greater part of

the once fertile plains of the coal formation again under the waters; and shifting sand-banks and muddy tides engulfed and buried the remains of the old forests, and heaped on them a mass of sediment, which, like the weights of a botanical press, flattened and compressed the vegetable *débris* preserved in the leaves of the coal formation strata. Then came on that strange and terrible Permian period, which, like the more modern boulder-formation, marked the death of one age and the birth of another.

The succession just sketched is the normal one; but the terms in which it has been described show that it cannot be universal. There are many places in which the whole thickness of the Carboniferous is filled with fossils of the land, and of estuaries and creeks. There are places, on the other hand, where the deep sea appears to have continued during the whole period. In America this is seen on the grandest scale in the absence of the marine members along the western slopes of the Appalachians, and the almost exclusive prevalence of marine beds in the far west, where the great Carboniferous Mediterranean of America spread itself, and continued uninterruptedly into the succeeding Permian period.

In our survey of the Carboniferous age, though there are peculiarities in the life of its older, middle, and newer divisions, we may take the great coal measures of the middle portion as the type of the land life of the period, and the great limestones of the lower portion as that of the marine life; and as

the former is in this period by far the most important, we may begin with it. Before doing so, however, to prevent misapprehension, it is necessary to remind the reader that the Flora of the Middle Coal Period is but one of a succession of related floras that reach from the Upper Silurian to the Permian. The meagre flora of club-mosses and their allies in the Upper Silurian and Lower Devonian was succeeded by a comparatively rich and varied assemblage of plants in the Middle Devonian. The Upper Devonian was a period of decadence, and in the Lower Carboniferous we have another feeble beginning, presenting features somewhat different from those of the Upper Devonian. This was the time of the Culm of Germany, the Tweedien formation of the North of England and South of Scotland, and the Lower Coal formation of Nova Scotia. It was a period eminently rich in Lepidodendra. It was followed by the magnificent flora of the Middle Coal formation, and then there was a time of decadence in the Upper Coal formation and only a slight revival in the Permian.

In the present condition of our civilization, coal is the most important product which the bowels of the earth afford to man. And though there are productive beds of coal in most of the later geological formations, down to the peats of the modern period, which are only unconsolidated coals, yet the coal of the Carboniferous age is the earliest valuable coal in point of time, and by far the most important in point of quantity. Mineral coal may be defined to

be vegetable matter which has been buried in the strata of the earth's crust, and there subjected to certain chemical and mechanical changes. The proof of its vegetable origin will grow upon us as we proceed. The chemical changes which it has undergone are not very material. Wood or bark, taken as an example of ordinary vegetable matter, consists of carbon or charcoal, with the gases hydrogen and oxygen. Coal has merely parted with a portion of these ingredients in the course of a slow and imperfect putrefaction, so that it comes to have much less oxygen and considerably less hydrogen than wood, and it has been blackened by the disengagement of a quantity of free carbon. The more bituminous flaming coals have a larger amount of residual hydrogen. In the anthracite coals the process of carbonisation has proceeded further, and little remains but charcoal in a dense and compact form. In cannel coals, and in certain bituminous shales, on the contrary, the process seems to have taken place entirely under water, by which putrefaction has been modified, so that a larger proportion than usual of hydrogen has been retained. The mechanical change which the coal has experienced consists in the flattening and hardening effect of the immense pressure of thousands of feet of superincumbent rock, which has crushed together the cell-walls of the vegetable matter, and reduced what was originally a pulpy mass of cellular tissue to the condition of a hard laminated rock. To understand this, perhaps the

simplest way is to compare under the microscope a transverse section of recent pine-wood with a similar section of a pine trunk compressed into brown coal or jet. In the one the tissue appears as a series of meshes with thin woody walls and comparatively wide cavities for the transmission of the sap. In the other the walls of the cells have been forced into direct contact, and in some cases have altogether lost their separate forms, and have been consolidated into a perfectly compact structureless mass.

With regard to its mode of occurrence, coal is found in beds ranging in vertical thickness from less than an inch to more than thirty feet, and of wide horizontal extent. Many such beds usually occur in the thickness of the coal formation, or "coal measures," as the miners call it, separated from each other by beds of sandstone and compressed clay or shale. Very often the coal occurs in groups of several beds, somewhat close to each other and separated from other groups by "barren measures" of considerable thickness. In examining a bed of coal, where it is exposed in a cutting or shore cliff, we nearly always find that the bed below it, or the "underclay," as it is termed by miners, is a sort of fossil soil, filled with roots and rootlets. On this rests the coal, which, when we examine it closely, is found to consist of successive thin layers of hard coal of different qualities as to lustre and purity, and with intervening laminæ of a dusty fibrous substance, like charcoal, called "mother coal" by miners, and sometimes mineral

charcoal. Thin partings of dark shale also occur, and these usually present marks and impressions of the stems and leaves of plants. Above the coal is its "roof" of hardened clay or sandstone, and this generally holds great quantities of remains of plants, and sometimes large stumps of trees with their bark converted into coal, and the hollow once occupied with wood filled with sandstone, while their roots spread over the surface of the coal. Such fossil forests of erect stumps are also found at various levels in the coal measures, resting directly on under-clays without any coals. A bed of coal would thus appear to be a fossil bog or swamp.

This much being premised about the general nature of the sooty blocks which fill our coal-scuttles, we may now transport ourselves into the forests and bogs of the coal formation, and make acquaintance with this old vegetation, while it still waved its foliage in the breeze and drank in the sunshine and showers. We are in the midst of one of those great low plains formed by the elevation of the former sea bed. The sun pours down its fervent rays upon us, and the atmosphere, being loaded with vapour, and probably more rich in carbonic acid than that of the present world, the heat is as it were accumulated and kept near the surface, producing a close and stifling atmosphere like that of a tropical swamp. This damp and oppressive air is, however, most favourable to the growth of the strange and grotesque trees which tower over our heads, and

to the millions of delicate ferns and club-mosses, not unlike those of our modern woods, which carpet the ground. Around us for hundreds of miles spreads a dense and monotonous forest, with here and there open spaces occupied by ponds and sluggish streams, whose edges are bordered with immense savannahs of reed-like plants, springing from the wet and boggy soil. Everything bespeaks a rank exuberance of vegetable growth; and if we were to dig downward into the soil, we should find a thick bed of vegetable mould evidencing the prevalence of such conditions for ages. But the time will come when this immense flat will meet with the fate which in modern times befel a large district at the mouth of the Indus. Quietly, or with earthquake shocks, it will sink under the waters; fishes and mollusks will swarm where trees grew, beds of sand and mud will be deposited by the water, inclosing and preserving the remains of the vegetation, and in some places surrounding and imbedding the still erect trunks of trees. Many feet of such deposits may be formed, and our forest surface, with its rich bed of vegetable mould, has been covered up and is in process of transformation into coal; while in course of time the shallow waters being filled up with deposit, or a slight re-elevation occurring, a new forest exactly like the last will flourish on the same spot. Such changes would be far beyond the compass of the life even of a Methuselah; but had we lived in the Coal period, we might have seen all stages of these

processes contemporaneously in different parts of either of the great continents.

But let us consider the actual forms of vegetation presented to us in the Coal period, as we can restore them from the fragments preserved to us in the beds of sandstone and shale, and as we would have seen them in our imaginary excursion through the Carboniferous forests. To do this we must first glance slightly at the great subdivisions of modern plants, which we may arrange in such a way as to give an easy means for comparison of the aspects of the vegetable kingdom in ancient and modern times. In doing this I shall avail myself of an extract from a previous publication of my own on this subject.

“The modern flora of the earth admits of a grand twofold division into the *Phænogamous*, or flowering and seed-bearing plants, and the *Cryptogamous*, or flowerless and spore-bearing plants. In the former series, we have, first, those higher plants which start in life with two seed-leaves, and have stems with distinct bark, wood, and pith—the *Exogens*; secondly, those similar plants which begin life with one seed-leaf only, and have no distinction of bark, wood, and pith, in the stem—the *Endogens*; and, thirdly, a peculiar group starting with two or several seed-leaves, and having a stem with bark, wood, and pith, but with very imperfect flowers, and wood of much simpler structure than either of the others—the *Gymnosperms*. To the first of these groups or classes

belong most of the ordinary trees of temperate climates. To the second belong the palms and allied trees found in tropical climates. To the third belong the pines and cycads. In the second or Cryptogamous series we have also three classes,—(1.) The *Acrogens*, or ferns and club-mosses, with stems having true vessels marked on the sides with cross-bars—the Scalariform vessels. (2.) The *Anophytes*, or mosses and their allies, with stems and leaves, but no vessels. (3.) The *Thallophytes*, or lichens, fungi, sea-weeds, etc., without true stems and leaves.

“In the existing climates of the earth we find these classes of plants variously distributed as to relative numbers. In some, pines predominate. In others, palms and tree-ferns form a considerable part of the forest vegetation. In others, the ordinary exogenous trees predominate, almost to the exclusion of others. In some Arctic and Alpine regions, mosses and lichens prevail. In the Coal period we have found none of the higher Exogens, though one species is known in the Devonian, and only a few obscure indications of the presence of Endogens; but Gymnosperms abound, and are highly characteristic. On the other hand, we have no mosses or lichens, and very few algæ, but a great number of ferns and Lycopodiaceæ or club-mosses. Thus the coal formation period is botanically a meeting-place of the lower Phænogams and the higher Cryptogams, and presents many forms which,

when imperfectly known, have puzzled botanists in regard to their position in one or other series. In the present world, the flora most akin to that of the Coal period is that of moist and warm islands in the southern hemisphere. It is not properly a tropical flora, nor is it the flora of a cold region, but rather indicative of a moist and equable climate. In accordance with this is the fact that the equable but not warm climate of the southern hemisphere at present (which is owing principally to its small extent of land) enables sub-tropical plants to extend into high latitudes. In the Coal period this uniformity was evidently still more marked, since we find similar plants extending from regions within the Arctic circle to others near to the tropics. Still we must bear in mind that we may often be mistaken in reasoning as to the temperature required by extinct species of plants differing from those now in existence. Further, we must not assume that the climatal conditions of the northern hemisphere were in the Coal period at all similar to those which now prevail. As Sir Charles Lyell has argued, a less amount of land in the higher latitudes would greatly modify climates, and there is every reason to believe that in the Coal period there was less land than now. It has been shown by Tyndall that a very small additional amount of carbonic acid in the atmosphere would, by obstructing the radiation of heat from the earth, produce almost the effect of a glass roof or conservatory, extending over the

whole world. There is much in the structure of the leaves of the coal plants, as well as in the vast amount of carbon which they accumulated in the form of coal, and the characteristics of the animal life of the period, to indicate, on independent grounds, that the Carboniferous atmosphere differed from that of the present world in this way, or in the presence of more carbonic acid—a substance now existing in the very minute proportion of one-thousandth of the whole by weight, a quantity adapted to the present requirements of vegetable and animal life, but probably not to those of the Coal period.

Returning from this digression to the forests of the Coal period, we may first notice that which is the most conspicuous and abundant tree in the swampy levels—the *Sigillaria* or seal-tree, so called from the stamp-like marks left by the fall of its leaves—a plant which has caused much discussion as to its affinities. Some regard it as a gymnosperm, others as a cryptogam. Most probably we have under this name trees allied in part to both groups, and which, when better known, may bridge over the interval between them. These trees present tall pillar-like trunks, often ribbed vertically with raised bands, and marked with rows of scars left by the fallen leaves. They are sometimes branchless, or divide at top into a few thick limbs, covered with long rigid grass-like foliage. On their branches they bear long slender spikes of fruit, and we may conjecture that quantities of nut-like seeds scattered over the ground around their trunks are

their produce. If we approach one of these trees closely, more especially a young specimen not yet furrowed by age, we are amazed to observe the accurate regularity and curious forms of the leaf-scars, and the regular ribbing, so very different from that of our ordinary forest trees. If we cut into its stem, we are still further astonished at its singular structure. Externally it has a firm and hard rind. Within this is a great thickness of soft cellular inner bark, traversed by large bundles of tough fibres. In the centre is a core or axis of woody matter very slender in proportion to the thickness of the trunk, and still further reduced in strength by a large cellular pith. Thus a great stem four or five feet in diameter is little else than a mass of cellular tissue, altogether unfit to form a mast or beam, but excellently adapted, when flattened and carbonised, to blaze upon our winter hearth as a flake of coal. The roots of these trees were perhaps more singular than their stems; spreading widely in the soft soil by regular bifurcation, they ran out in long snake-like cords, studded all over with thick cylindrical rootlets, which spread from them in every direction. They resembled in form, and probably in function, those cable-like root-stocks of the pond-lilies which run through the slime of lakes, but the structure of the rootlets was precisely that of those of some modern Cycads. It was long before these singular roots were known to belong to a tree. They were supposed to be the branches of some creeping aquatic plant, and botanists objected to the idea of their being

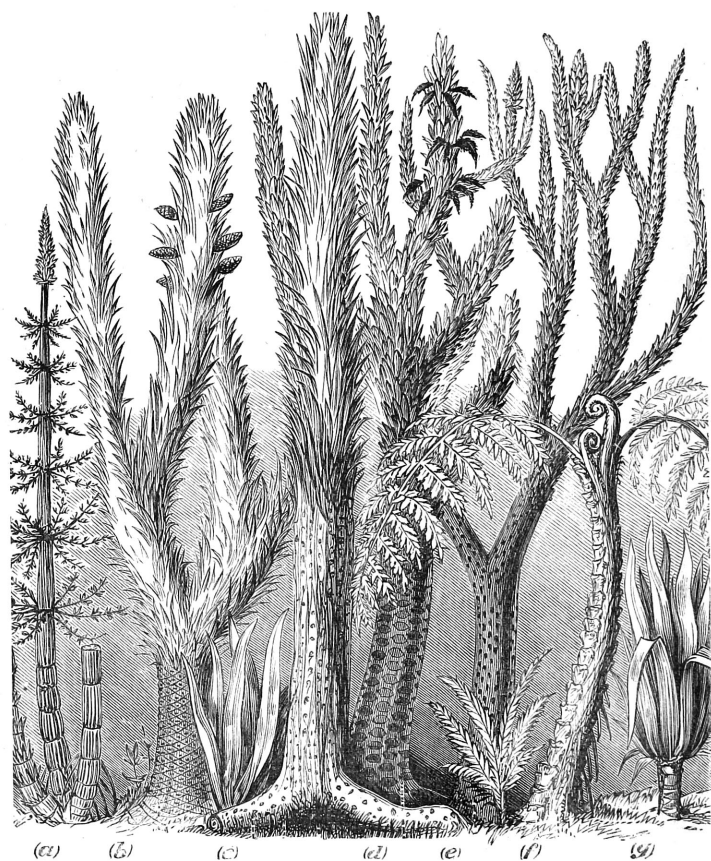


Fig. 13.—GROUP OF CARBONIFEROUS PLANTS, RESTORED FROM ACTUAL SPECIMENS.

(a) CALAMITES (type of *C. Suckovii*). (b) LEPIDOFLOIOS, OR ULODENDRON. (c) SIGILLARIA (type of *S. reniformis*). (d) (type of *S. elegans*). (e) LEPIDODENDRON (type of *L. corrugatum*). (f) MEGAPHYTON (type of *M. magnificum*). (g) CORDAITES, OR PYCHNOPHYLLUM (type of *C. borassifolia*).

roots ; but at length their connection with *Sigillaria* was observed simultaneously by Mr. Binney, in Lancashire, and by Mr. Richard Brown, in Cape Breton, and it has been confirmed by many subsequently observed facts. This connection, when once established, further explained the reason of the almost universal occurrence of *Stigmaria*, as these roots were called, under the coal beds ; while trunks of the same plants were the most abundant fossils of their partings and roofs. The growth of successive generations of *Sigillariae* was, in fact, found to be the principal cause of the accumulation of a bed of coal. Two species form the central figures in our illustration.

Along with the trees last mentioned, we observe others of a more graceful and branching form, the successors of those *Lepidodendra* already noticed in the Devonian, and which still abound in the Carboniferous, and attain to larger dimensions than their older relations, though they are certainly more abundant and characteristic in the lower portions of the carboniferous. Relatives, as already stated, of our modern club-mosses, now represented only by comparatively insignificant species, they constitute the culmination of that type, which thus had attained its acme very long ago, though it still continues to exist under depauperated forms. They all branched by bifurcation, sometimes into the most graceful and delicate sprays. They had narrow slender leaves, placed in close spirals on the branches. They bore their spores in scaly cones. Their roots were similar to

Stigmaria in general appearance, though differing in details. In the coal period there were several generic forms of these plants, all attaining to the dimensions of trees. Like the Sigillariæ, they contributed to the materials of the coal; and one mode of this has recently attracted some attention. It is the accumulation of their spores and spore-cases already referred to in speaking of the Devonian, and which was in the Carboniferous so considerable as to constitute an important feature locally in some beds of coal. A similar modern accumulation of spore-cases of tree-ferns occurs in Tasmania; but both in the Modern and the Carboniferous, such beds are exceptional; though wherever spore-cases exist as a considerable constituent of coal, from their composition they give to it a highly bituminous character, an effect, however, which is equally produced by the hard scales supporting the spores, and by the outer epidermal tissues of plants when these predominate in the coal, more especially by the thick corky outer bark of Sigillaria. In short, the corky substance of bark and similar vegetable tissues, from its highly carbonaceous character, its indestructibility, and its difficult permeability by water carrying mineral matter in solution, is the best of all materials for the production of coal; and the microscope shows that of this the principal part of the coal is actually composed.

In the wide, open forest glades, tree-ferns almost precisely similar to those of the modern tropics reared their leafy crowns. But among them was one peculiar

type, in which the fronds were borne in pairs on opposite sides of the stem, leaving when they fell two rows of large horseshoe-shaped scars marking the sides of the trunk. Botanists, who have been puzzled with these plants almost as much as with the *Stigmaria*, have supposed these scars to be marks of branches, of cones, and even of aerial roots; but specimens in my collection prove conclusively that the stem of this genus was a great caudex made up of the bases of two rows of huge leaves cemented together probably by intervening cellular tissue. As in the Devonian and in modern times, the stems of the tree-ferns of the Carboniferous strengthened themselves by immense bundles of cord-like aerial roots, which look like enormous fossil brooms, and are known under the name *Psaronius*.

We have only time to glance at the vast brakes of tall *Calamites* which fringe the *Sigillaria* woods, and stretch far seaward over tidal flats. They were allied to modern Mares' Tails or *Equisetums*, but were of gigantic size, and much more woody structure of stem. The *Calamites* grew on wet mud and sand-flats, and also in swamps; and they appear to have been especially adapted to take root in and clothe and mat together soft sludgy material recently deposited or in process of deposition. When the seed or spore of a *Calamite* had taken root, it probably produced a little low whorl of leaves surrounding one small joint, from which another and another, widening in size, arose, producing a cylindrical stem, tapering to

a point below. To strengthen the unstable base, the lower joints, especially if the mud had been accumulating around the plant, shot out long roots instead of leaves, while secondary stems grew out of the sides at the surface of the soil, and in time there was a stool of Calamites, with tufts of long roots stretching downwards, like an immense brush, into the mud. When Calamites thus grew on inundated flats, they would, by causing the water to stagnate, promote the elevation of the surface by new deposits, so that their stems gradually became buried; but this only favoured their growth, for they continually pushed out new stems, while the old buried ones shot out bundles of roots instead of regular whorls of leaves.

The Calamites, growing in vast fields along the margins of the Sigillaria forests, must have greatly protected these from the effects of inundations, and by collecting the mud brought down by streams in times of flood, must have done much to prevent the intrusion of earthy deposits among the vegetable matter. Their chief office, therefore, as coal-producers, seems to have been to form for the Sigillaria forests those reedy fringes which, when inundations took place, would exclude mud, and prevent that mixture of earthy matter in the coal which would have rendered it too impure for use. Quantities of fragments of their stems can, however, be detected by the microscope in most coals.

The modern Mares' Tails have thin-walled hollow stems, and some of the gigantic calamites of the coal

resembled them in this. But others, to which the name *Calamodendron*, or Reed-tree, has been given, had stems with thick woody walls of a remarkable structure, which, while similar in plan to that of the Mares' Tails, was much more perfect in its development. Professor Williamson has shown that there were forms intervening between these extremes; and thus in the calamites and calamodendrons we have another example of the exaltation in ancient times of a type now of humble structure; or, in other words, of a comprehensive type, low in the modern world, but in older periods taking to itself by anticipation the properties afterward confined to higher forms. The gigantic club-mosses of the Coal period constitute a similar example, and it is very curious that both of these types have been degraded in the modern world, though retaining precisely their general aspect, while the tree-ferns contemporary with them in the Palæozoic still survive in all their original grandeur.

Rarely in the swampy flats, perhaps more frequently in the uplands, grew great pines of several kinds; trees capable of doing as good service for planks and beams as many of their modern successors, but which lived before their time, and do not appear even to have aided much in the formation of coal. These pines of the Coal-period seem to have closely resembled some species still living in the southern hemisphere; and, like the ferns, they present to us a vegetable type which has endured through vast periods of time almost unchanged. Indeed, in the Middle

Devonian we have pines almost as closely resembling those of the Modern world as do those of the Coal period. It is in accordance with this long duration of the ferns and pines, that they are plants now of world-wide distribution—suited to all climates and stations. Capacity to exist under varied conditions is near akin to capacity to survive cosmical changes. A botanist in the strange and monstrous woods which we have tried to describe, would probably have found many curious things among the smaller herbaceous plants, and might have gathered several precursors of the modern Exogens and Endogens which have not been preserved to us as fossils, or are known only as obscure fragments. But incomplete though our picture necessarily is, and obscured by the dust of time, it may serve in some degree to render green to our eyes those truly primeval forests which treasured up for our long winter nights the Palæozoic sunshine, and established for us those storehouses of heat-giving material which work our engines and propel our ships and carriages. Truly they lived not in vain, both as realizing for us a type of vegetation which otherwise we could not have imagined, and as preparing the most important of all the substrata of our modern arts and manufactures. In this last regard even the vegetable waste of the old coal swamps was most precious to us, as the means of producing the clay iron ores of the coal measures. I may close this notice of the Carboniferous forests with a suggestive extract from a paper by Professor Huxley in the *Contemporary Review* :—

“Nature is never in a hurry, and seems to have had always before her eyes the adage, ‘Keep a thing long enough, and you will find a use for it.’ She has kept her beds of coal for millions of years without being able to find much use for them; she has sent them down beneath the sea, and the sea-beasts could make nothing of them; she has raised them up into dry land and laid the black veins bare, and still for ages and ages there was no living thing on the face of the earth that could see any sort of value in them; and it was only the other day, so to speak, that she turned a new creature out of her workshop, who by degrees acquired sufficient wits to make a fire, and then to discover that the black rock would burn.

“I suppose that nineteen hundred years ago, when Julius Cæsar was good enough to deal with Britain as we have dealt with New Zealand, the primeval Briton, blue with cold and woad, may have known that the strange black stone, of which he found lumps here and there in his wanderings, would burn, and so help to warm his body and cook his food. Saxon, Dane, and Norman swarmed into the land. The English people grew into a powerful nation, and Nature still waited for a return for the capital she had invested in the ancient club-mosses. The eighteenth century arrived, and with it James Watt. The brain of that man was the spore out of which was developed the steam-engine, and all the prodigious trees and branches of modern industry which have grown out of this. But coal is as much an essential condition of

this growth and development as carbonic acid is for that of a club-moss. Wanting the coal, we could not have smelted the iron needed to make our engines, nor have worked our engines when we had got them. But take away the engines, and the great towns of Yorkshire and Lancashire vanish like a dream. Manufactures give place to agriculture and pasture, and not ten men could live where now ten thousand are amply supported.

“Thus all this abundant wealth of money and of vivid life is Nature’s investment in club-mosses and the like so long ago. But what becomes of the coal which is burnt in yielding the interest? Heat comes out of it, light comes out of it, and if we could gather together all that goes up the chimney and all that remains in the grate of a thoroughly-burnt coal fire, we should find ourselves in possession of a quantity of carbonic acid, water, ammonia, and mineral matters, exactly equal in weight to the coal. But these are the very matters with which Nature supplied the club-moss which made the coal. She is paid back principal and interest at the same time; and she straightway invests the carbonic acid, the water, and the ammonia in new forms of life, feeding with them the plants that now live. Thrifty Nature! surely no prodigal, but most notable of housekeepers!”

All this is true and admirably put. Its one weak point is the poetical personification of Nature as an efficient planner of the whole. Such an imaginary goddess is a mere superstition, unknown alike to

science and theology. Surely it is more rational to hold that the mind which can utilize the coal and understand the manner of its formation, is itself made in the image and likeness of the Supreme Creative Spirit, in whom we live and move and have our being, who knows the end from the beginning, whose power is the origin of natural forces, whose wisdom is the source of laws and correlations of laws, and whose great plan is apparent alike in the order of nature of the Palæozoic world and of the modern world, as well as in the relation of these to each other.

In the Carboniferous, as in the Devonian age, insects existed, and in greater numbers. The winged insects of the period, so far as known, belong to three of the nine or ten orders into which modern insects are usually divided. Conspicuous among them are representatives of our well-known domestic pests the cockroaches, which thus belong geologically to a very old family. The Carboniferous roaches had not the advantage of haunting our larders, but they had abundance of vegetable food in the rank forests of their time, and no doubt lived much as the numerous wild out-of-door species of this family now do. It is, however, a curious fact that a group of insects created so long ago, should prove themselves capable of the kind of domestication to which these creatures attain in our modern days; and that, had we lived even so far back as the coal period, we might have been liable to the attacks of this particular kind of pest. Another group, represented by many species in the coal

forests, was that of the May-flies and shad-flies, or ephemeras, which spend their earlier days under water, feeding on vegetable matter, and affording food to many fresh-water fishes—a use which they no doubt served in the coal period also. Some of them were giants in their way, being probably seven inches in expanse of wing, and their larvæ must have been choice morsels to the ganoid fishes, and would have afforded abundant bait had there been anglers in those days. Another group of insects was that of the weevils, a family of beetles, whose grubs must have found plenty of nuts and fruits to devour, without attracting the wrathful attentions of any gardener or orchardist.

A curious and exceptional little group of creatures in the present world is that of the galley-worms or millipedes; wingless, many-jointed, and many-footed crawlers, resembling worms, but more allied to insects. These animals seem to have swarmed in the coal forests, and perhaps attained their maximum numbers and importance in this period, though they still remain, a relic of an ancient comprehensive type. I have myself found specimens referred by Mr. Scudder, a most competent entomologist, to two genera and five species, in a few decayed fossil stumps in Nova Scotia, and several others have been discovered in other parts of the world. It is not wonderful that animals like these, feeding on decayed vegetable matter, should have flourished in the luxuriant *Sigillaria* swamps. A few species of scor-

pions and spiders, very like those of the modern world, have been found in the coal measures, both in Europe and America; so that while we know of no enemy of the Devonian insects except the fishes, we know in addition to these in the Carboniferous the spiders and their allies, and the smaller reptiles or batrachians to be noticed in the sequel. With reference to the latter, it is a curious fact that one of the first fragments of a winged insect found in the coal-fields of America was a part of a head and some other remains contained in the coprolites or excrementitious matter of one of the smaller fossil reptiles. It is perhaps equally interesting that this head shows one of the compound faceted eyes as perfectly developed as those of any modern Neuropter, a group of insects remarkable even in the present world for their large and complex organs of vision. We may pause here to note that, just as in the Primordial we already have the Trilobites presenting all the modifications of which the type is susceptible, so in the Carboniferous we have in the case of the terrestrial articulates a similar fact—highly specialised forms like the beetles, the spiders, and the scorpions, already existing along with comprehensive forms like the millipedes. Let us formulate the law of creation which the Primordial trilobites, the Devonian fishes, and the Carboniferous club-mosses and insects have taught us: it is, that every new type rapidly attains its maximum of development in magnitude and variety of forms, and then remains stationary, or even retrogrades, in subsequent

ages. We may connect this with other laws in the sequel.

In the coal measures we also meet, for the first time in our ascending progress, the land snails so familiar now in every part of the world, and which are represented by two little species found in the coal formation of Nova Scotia. The figures of these must speak for themselves; but the fact of their occurrence here and the mode of their preservation require some detailed mention. The great province of the Mollusks we have carried with us since we met with the *Lingulæ* in the Primordial, but all its members have been aquatic, and probably marine. For the first time, in the Carboniferous period, snails emerge from the waters, and walk upon the ground and breathe air; for, like the modern land snails, these creatures no doubt had air-sacks instead of gills. They come suddenly upon us—two species at once, and these representing two distinct forms of the snail tribe, the elongated and the rounded. They were very numerous. In the beds where they occur, probably thousands of specimens, more or less perfect, could be collected. Were they the first-born of land snails? It would be rash to affirm this, more especially since in all the coal-fields of the world no specimens have been found except at one locality in Nova Scotia;* and in all the succeeding beds we meet with no more till we have reached a comparatively modern time. Yet

* Bradley has recently announced the discovery of other species in the coal-field of Illinois.

it is very unlikely that these creatures were in the coal period limited to one country, and that, after that period, they dropped out of existence for long ages, and then reappeared. Still it may have been so.

THE TWO OLDEST LAND SNAILS.

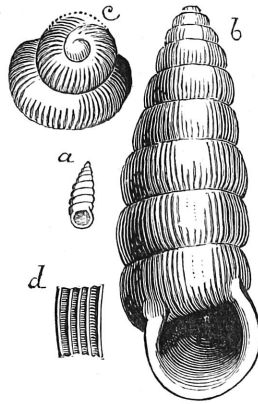


Fig. 14.—*Pupa Vetusta*, Dawson.
(a) Natural size. (b) Enlarged. (c) Apex, enlarged. (d) Sculpture, magnified.

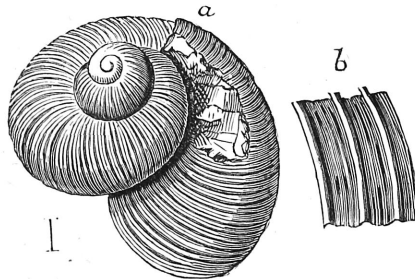


Fig. 15.—*Conulus Priscus*, Carpenter.
(a) Specimen enlarged. (b) Sculpture, magnified.

There are cases of geographical limitation quite as curious now. Here again another peculiarity meets

us. If these are really the oldest land snails, it is curious that they are so small,—so much inferior to many of their modern successors even in the same latitudes. The climate of the coal period must have suited them, and there was plenty of vegetable food, though perhaps not the richest or most tender. There is no excuse for them in their outward circumstances. Why, then, unlike so many other creatures, do they enter on existence in this poor and sneaking way. We must here for their benefit modify in two ways the statement broadly made in a previous chapter, that new types come in under forms of great magnitude. First, we often have, in advance of the main inroad of a new horde of animals, a few insignificant stragglers as a sort of prelude to the rest—precursors intimating beforehand what is to follow. We shall find this to be the case with the little reptiles of the coal, and the little mammals of the Trias, preceding the greater forms which subsequently set in. Secondly, this seems to be more applicable in the case of land animals than in the case of those of the waters. To the waters was the fiat to bring forth living things issued. They have always kept to themselves the most gigantic forms of life; and it seems as if new forms of life entering on the land had to begin in a small way and took more time to culminate.

The circumstances in which the first specimens of Carboniferous snails and gally-worms were found are so peculiar and so characteristic of the coal formation, that I must pause here to notice them, and to make of

them an introduction to the next group of creatures we have to consider. In the coal formation in all parts of the world it is not unusual, as stated already in a previous page, to find erect trees or stumps of trees, usually *Sigillariæ*, standing where they grew ; and where the beds are exposed in coast cliffs, or road cuttings, or mines, these fossil trees can be extracted from the matrix and examined. They usually consist of an outer cylinder of coal representing the outer bark, while the space within, once occupied by the inner bark and wood, is filled with sandstone, sometimes roughly arranged in layers, the lowest of which is usually mixed with coaly matter or mineral charcoal derived from the fallen remains of the decayed wood, a kind of deposit which affords to the fossil botanist one of the best modes of investigating the tissues of these trees. These fossil stumps are not uncommon in the roofs of the coal-seams. In some places they are known to the miners as "coal pipes," and are dreaded by them in consequence of the accidents which occur from their suddenly falling after the coal which supported them has been removed. An old friend and helper of mine in Carboniferous explorations had a lively remembrance of the fact that one of these old trees, falling into the mine in which he was working, had crushed his leg and given him a limp for life ; and if he had been a few inches nearer to it would have broken his back.

The manner in which such trees become fossilized may be explained as follows:—Imagine a forest of

Sigillariæ growing on a low flat. This becomes submerged by subsidence or inundation, the soil is buried under several feet of sand or mud, and the trees killed by this agency stand up as bare and lifeless trunks. The waters subside, and the trees rapidly decay, the larvæ of wood-boring insects perhaps aiding in the process, as they now do in the American woods. The dense coaly outer bark alone resists decomposition, and stands as a hollow cylinder until prostrated by the wind or by the waters of another inundation, while perhaps a second forest or jungle has sprung up on the new surface. When it falls, the part buried in the soil becomes an open hole, with a heap of shreds of wood and bark in the bottom. Such a place becomes a fit retreat for gally-worms and land-snails; and reptiles pursuing such animals, or pursued by their own enemies, or heedlessly scrambling among the fallen trunks, may easily fall into such holes and remain as prisoners. I remember to have observed, when a boy, a row of post-holes dug across a pasture-field and left open for a few days, and that in almost every hole one or two toads were prisoners. This was the fate which must have often befallen the smaller reptiles of the coal forests in the natural post-holes left by the decay of the Sigillariæ. Yet it may be readily understood that the combination of circumstances which would effect this result must have been rare, and consequently this curious fact has been as yet observed only in the coal formation of Nova Scotia; and in it only in one locality, and in

this in one only out of more than sixty beds in which erect trees have been found. But these hollow trees must be filled up in order to preserve their contents; and as inundation and subsequent decay have been the grave-diggers for the reptiles, so inundations filled up their graves with sand, to be subsequently hardened into sandstone, burying up at the same time the newer vegetation which had grown upon the former surface. The idea that something interesting might be found in these erect stumps, first occurred to Sir C. Lyell and the writer while exploring the beautiful coast cliffs of Western Nova Scotia in 1851; and it was in examining the fragments scattered on the beach that we found the bones of the first Carboniferous reptile discovered in America, and the shell of the oldest known land snail.

These were not, however, the earliest known instances of Carboniferous reptiles. In 1841, Sir William Logan found footprints of a reptile at Horton Bluff, in Nova Scotia, in rocks of Lower Carboniferous age. In 1844, Von Dechen found reptilian bones in the coal-field of Saarbruck; and in the same year Dr. King found reptilian footprints in the Carboniferous of Pennsylvania. Like Robinson Crusoe on his desert island, we saw the footprints before we knew the animals that produced them; and the fact that there were marks on a slab of shale or sandstone that must have been made by an animal walking on feet, was as clear and startling a revelation of the advent of a new and higher form of life, as were the footprints of Man

Friday. Within the thirty years since the discovery of the first slab of footprints, the knowledge of coal formation reptiles has grown apace. I can scarcely at present sum up exactly the number of species, but may estimate it at thirty-five at least. I must, however, here crave pardon of some of my friends for the use of the word reptile. In my younger days frogs and toads and newts used to be reptiles; now we are told that they are more like fishes, and ought to be called Batrachians or Amphibians, whereas reptiles are a higher type, more akin to birds than to these lower and more grovelling creatures. The truth is, that the old class Reptilia bridges over the space between the fishes and the birds, and it is in some degree a matter of taste whether we make a strong line at the two ends of it alone, or add another line in the middle. I object to the latter course, however, in the period of the world's history of which I am now writing, since I am sure that there were animals in those days which were batrachians in some points and true reptiles in others; while there are some of them in regard to which it is quite uncertain whether they are nearer to the one group or the other. Although, therefore, naturalists, with the added light and penetration which they obtain by striding on to the Mesozoic and Modern periods, may despise my old-fashioned grovellers among the mire of the coal-swamps, I shall, for convenience, persist in calling them reptiles in a general way, and shall bring out whatever claims I can to justify this title for some of them at least.

Perhaps the most fish-like of the whole are the curious creatures from the coal measures of Saarbruck, first found by Von Dechen, and which constitute the genus *Archegosaurus*. Their large heads, short necks, supports for permanent gills, feeble limbs, and long tails for swimming, show that they were aquatic creatures presenting many points of resemblance to the ganoid fishes with which they must have associated; still they were higher than these in possessing lungs and true feet, though perhaps better adapted for swimming than even for creeping.

From these creatures the other coal reptiles diverge, and ascend along two lines of progress, the one leading to gigantic crocodile-like animals provided with powerful jaws and teeth, and probably haunting the margins of the waters and preying on fishes; the other leading to small and delicate lizard-like species, with well-developed limbs, large ribs, and ornate horny scales and spines, living on land and feeding on insects and similar creatures.

In the first direction we have a considerable number of species found in the Jarrow coal-field in Ireland, and described by Professor Huxley. Some of them were like snakes in their general form, others more like lizards. Still higher stand such animals as *Baphetes* and *Eosaurus* from the Nova Scotia coal-field and *Anthracosaurus* from that of Scotland. The style and habits of these creatures it is easy to understand, however much haggling the comparative anatomists may make over their bones. They were animals of

various size, ranging from a foot to at least ten feet in length; the body generally lizard-like in form, with stout limbs and a flattened tail useful in swimming. Their heads were flat, stout, and massive, with



Fig. 16.—RESTORATIONS OF BAPHETES, DENDRERPETON, HYLONOMUS, AND HYLERPETON, WITH CARBONIFEROUS PLANTS IN THE DISTANCE.

large teeth, strengthened by the insertion and convolution of plates of enamel. The fore limbs were probably larger than the hind limbs, the better to enable them to raise themselves out of the water.

The belly was strengthened by bony plates and closely imbricated scales, to resist, perhaps, the attacks of fishes from beneath, and to enable them without injury to drag their heavy bodies over trunks of trees and brushwood, whether in the water or on the land. Their general aspect and mode of life were therefore by no means unlike those of modern alligators; and in the vast swamps of the coal measures, full of ponds and sluggish streams swarming with fish, such creatures must have found a most suitable habitat, and probably existed in great numbers, basking on the muddy banks, surging through the waters, and filling the air with their bellowings. The most curious point about these creatures is, that while rigid anatomy regards them as allied in structure more to frogs and toads and newts than to true lizards, it is obvious to common sense that they were practically crocodiles; and even anatomy must admit that their great ribs and breastplates, and powerful teeth and limbs, indicate a respiration, circulation, and general vitality, quite as high as those of the proper reptiles. Hence, it happens that very different views are stated as to their affinities; questions into which we need not now enter, satisfied with the knowledge of the general appearance and mode of life of these harbingers of the reptilian life of the succeeding geological periods.

In the other direction, we find several animals of small size but better developed limbs, leading to a group of graceful little creatures, quite as perplexing with regard to affinities as those first mentioned, but

tending towards the smaller lizards of the modern world. At the top of these I may place the genus *Hylonomus* from hollow fossil trees of Nova Scotia, of which two species are represented as restored in our illustration. In these restorations I have adhered as faithfully as possible to the proportions of parts as seen in my specimens. Imagine a little animal six or seven inches long, with small short head, not so flat as those of most lizards, but with a raised forehead, giving it an aspect of some intelligence. Its general form is that of a lizard, but with the hind feet somewhat large, to aid it in leaping and standing erect, and long and flexible toes. Its belly is covered with bony scales, its sides with bright and probably coloured scale armour of horny consistency, and its neck and back adorned with horny crests, tubercles, and pendants. It runs, leaps, and glides through the herbage of the coal forests, intent on the pursuit of snails and insects, its eye glancing and its bright scales shining in the sun. This is a picture of the best known species of *Hylonomus* drawn from the life. Yet the anatomist, when he examines the imperfectly-ossified joints of its backbone, and the double joint at the back of its skull, will tell you that it is after all little better than a mere newt, an ass in a lion's skin, a jackdaw with borrowed feathers, and that it has no right to have fine scales, or to be able to run on the land. It may be so; but I may plead in its behalf, that in the old coal times, when reptiles with properly-made skeletons had not been

created, the next best animals may have been entitled to wear their clothes and to assume their functions as well. In short, functionally or officially, our ancient batrachians were reptiles; in point of rank, as measured by type of skeleton, they belonged to a lower grade. To this view of the case I think most naturalists will agree, and they will also admit that the progress of our views has been in this direction, since the first discovery of Carboniferous air-breathing vertebrates. In evidence of this I may quote from Professor Huxley's description of his recently found species.* After noticing the prevalent views that the coal reptiles were of low organization, he says: "Discoveries in the Nova Scotia coal-fields first shook this view, which ceased to be tenable when the great *Anthracosaurus* of the Scotch coal-field was found to have well-ossified biconcave vertebræ."

The present writer may, however, be suspected of a tendency to extend forms of life backward in time, since it has fallen to his lot to be concerned in this process of stretching backward in several cases. He has named and described the oldest known animal. He has described the oldest true exogen, and the oldest known pine-tree. He was concerned in the discovery of the oldest known land snails, and found the oldest millipedes. He has just described the oldest bituminous bed composed of spore-cases, and he claims that his genus *Hylonomus* includes the

* *Geological Magazine*, vol. iii.

oldest animals which have a fair claim to be considered reptiles. Still this discovery of old things comes rather of fortune and careful search than of a desire to innovate; and a distinction should be drawn between that kind of novelty which consists in the development of new truths, and that which consists in the invention of new fancies, or the revival of old ones. There is too much of this last at present; and it would be a more promising line of work for our younger naturalists, if they would patiently and honestly question nature, instead of trying to extort astounding revelations by throwing her on the rack of their own imaginations.

We may pause here a moment to contemplate the greatness of the fact we have been studying—the introduction into our world of the earliest known vertebrate animals which could open their nostrils and literally “breathe the breath of life.” All previous animals that we know, except a few Devonian insects, had respired in the water by means of gills or similar apparatus. Now we not only have the little land snails, with their imperfect substitutes for lungs, but animals which must have been able to draw in the vital air into capacious chambered lungs, and with this power must have enjoyed a far higher and more active style of vitality; and must have possessed the faculty of uttering truly vocal sounds. What wondrous possibilities unknown to these creatures, perhaps only dimly perceived by such rational intelligences as may have watched the growth of our

young world, were implied in these gifts. It is one of the remarkable points in the history of creation in Genesis, that this step of the creative work is emphatically marked. Of all the creatures we have noticed up to this point, it is stated that God said, "Let the waters bring them forth,"—but it is said that "God created" great reptiles (*tanninim*).* No doubt these "great tanninim" culminate in the succeeding Mesozoic age, but their first introduction dates as far back as the Carboniferous; and this introduction was emphatically a creation, as being the commencement of a new feature among living beings. What further differences may be implied in the formulæ, "Let the waters produce" and "God created," we do not know; very probably he who wrote the words did not fully know. But if we could give a scientific expression to this difference, and specify the cases to which its terms apply, we might be able to solve one of the most vexed questions of biology.

Let us observe, however, that even here, where, if anywhere, we have actual creation, especial pains are taken to bridge over the gap, and to prevent any appearance of discontinuity in the work. The ganoid fishes of the coal period very probably had, like their modern congeners, well-developed air-bladders, serving to some extent, though very imperfectly, as lungs. The humbler and more aquatic reptiles of the period retained the gills, and also some of the other features

* Not "whales," as in our version.

of the fishes ; so that, like some modern creatures of their class, they stood, as to respiration, on two stools, and seemed unwilling altogether to commit themselves to the new mode of life in the uncongenial element of air. Even the larger and more lizard-like of the coal reptiles may—though this we do not certainly know, and in some cases there are reasons for doubting it—have passed the earliest stage of their lives in the water as gilled tadpoles, in the manner of our modern frogs. Thus at the very point where one of the greatest advances of animal life has its origin, we have no sudden stop, but an inclined plane ; and yet, as I have elsewhere endeavoured to show by arguments which cannot be repeated here,* we have not a shadow of reason to conclude that, in the coal period, fishes were transmuted into reptiles.

But the reader may be wearied with our long sojourn in the pestilential atmosphere of the coal swamps, and in the company of their low-browed and squalid inhabitants. Let us turn for a little to the sea, and notice the animal life of the great coral reefs and shell beds preserved for us in the Carboniferous limestone. Before doing so, one point merits attention. The coal formation for the first time distinctly presents to us the now familiar differences in the inhabitants of the open sea and those of creeks, estuaries and lakes. Such distinctions are unknown to us in the Silurian. There all is sea. They begin to

* "Air-breathers of the Coal Period," p. 77.

appear in the Devonian, in the shallow fish-banks and the Anodon-like bivalves found with fossil plants. In the coal period they become very manifest. The animals found in the shales with the coal are all, even the aquatic ones, distinct from those of the open seas of the period. Some of them may have lived in salt or brackish water, but not in the open sea. They are creatures of still and shallow waters. It is true that in some coal-fields marine beds occur in the coal measures with their characteristic fossils, but these are quite distinct from the usual animal remains of the coal-fields, and mark occasional overflows of the sea, owing to subsidence of the land. It is important to notice this geographical difference, marking the greater specialisation and division of labour, if we may so speak, that was in the process of introduction.

The sea of the Carboniferous period presented in the main similar great groups of animals to those of the Devonian, represented however by different species. We may notice merely some of the salient points of resemblance or difference. The old types of corals continue in great force; but it is their last time, for they rapidly decay in the succeeding Permian and disappear. The Crinoids are as numerous and beautiful as in any other period, and here for the first time we meet with the new and higher type of the sea-urchin, in large and beautiful species. One curious group, that of the *Pentremites*, a sort of larval form, is known here alone. Among the lamp-shells we may note, as peculiarly and abundantly Carboni-

ferous, those with one valve very convex and the other very concave and anchored in the mud by long spines instead of a peduncle attached to stones and rocks.* There are many beautiful shells allied to modern scallops, and not a few sea-snails of various sorts. The grand *Orthoceratites* of the Silurian diminish in size preparatory to their disappearance in the Permian, and the more modern type of *Nautilus* and its allies becomes prevalent. Among the Crustaceans we may notice the appearance of the *Limulus*, or king-crab, of which the single little species described by Woodward from the Upper Silurian may be regarded as merely a prophecy. It is curious that the Carboniferous king-crabs are very small, apparently another case of a new form appearing in humble guise; but as the young of modern king-crabs haunt creeks and swampy flats, while the adults live in the sea, it may be that only the young of the Carboniferous species are yet known to us, the specimens found being mostly in beds likely to be frequented by the young rather than by the full-grown individuals.

The old order of the Trilobites, which has accompanied us from Primordial times, here fails us, and a few depauperated species alone remain, the sole survivors of their ancient race—small, unornamented, and feeble representatives of a once numerous and influential tribe. How strange that a group of creatures so numerous and apparently so well adapted to conditions

* The Productidæ.

of existence which still continue in the sea, should thus die out, while the little bivalved crustaceans, which began life almost as far back and lived on the same sea-floors with the Trilobites, should still abound in all our seas; and while the king-crabs, of precisely similar habits with the Trilobites, should apparently begin to prosper. Equally strange is the fate of the great swimming Eurypterids which we saw in the Devonian. They also continue, but in diminished force, in the Carboniferous, and there lay down for ever their well-jointed cuirasses and formidable weapons, while a few little shrimp-like creatures, their contemporaries, form the small point of the wedge of our great tribes of squillas and crabs and lobsters. Some years ago the late lamented palæontologist, Salter, a man who scarcely leaves his equal in his department, in conjunction with Mr. Henry Woodward, prepared a sort of genealogical chart of the crustacea on which these facts are exhibited. Some new species have since been discovered, and a little additional light about affinities has been obtained; but taken as it stands, the history of the crustacea as there shown in one glance, has in it more teaching on the philosophy of creation than I have been able to find in many ponderous quartos of tenfold its pretensions. Had Salter been enabled, with the aid of other specialists like Woodward, to complete similar charts of other classes of invertebrate animals, scientific palæontology in England would have been further advanced than it is likely to be in the next ten years.

To return to our Trilobites: one of the most remarkable points in their history is their appearance in full force in the Primordial. In these rocks we have some of the largest in size—some species of Paradoxides being nearly two feet long, and some of the very smallest. We have some with the most numerous joints, others with the fewest; some with very large tails, others with very small; some with no ornamentation, others very ornate; some with large eyes, others with none that have been made out, though it is scarcely probable that they were wholly blind. They increased in numbers and variety through the Silurian and Devonian, and then suddenly drop off at the end of the Lower Carboniferous. Throughout their whole term of existence they kept rigidly to that type of the mud-plough which the king-crab still retains, and which renders the anterior extremity so different from that of the ordinary crustacea. They constitute one of the few cases in which we seem to see before us the whole history of an animal type; and the more we look into that history, the more do we wonder at their inscrutable introduction, the unity and variety mingled in their progress, and their strange and apparently untimely end. I have already referred (page 95) to the use which Barrande makes of this as an argument against theories of evolution; but must refer to his work for the details.

One word more I must say before leaving their graves. I have reason to believe that they were not only the diggers of the burrows, and of the

ladder-tracks and pitted tracks* of the Silurian and Primordial, but that with the strokes of their rounded or spinous tails, the digging of their snouts, and the hoe-work of their hard upper lips, or Hypostomes, they made nearly all those strange marks in the Primordial mud which have been referred to fucoids, and even to higher plants. The Trilobites worked over all the mud bottoms of the Primordial, even in places where no remains of them occur, and the peculiarities of the markings which they left are to be explained only by a consideration of the structures of individual species.

I had almost lost sight of the fishes of the Carboniferous period, but after saying so much of those of the Devonian, it would be unfair to leave their successors altogether unnoticed. In the Carboniferous we lose those broad-snouted plate-covered species that form so conspicuous a feature in the Devonian; and whatever its meaning, it is surely no accident that these mud-burrowing fishes should decay along with those crustacean mud-burrowers, the Trilobites. But swarms of fishes remain, confined, as in the Devonian, wholly to the two orders of the Gar-fishes (*Ganoids*) and the sharks (*Placoids*). In the former we have a multitude of small and beautiful species haunting the creeks and ponds of the coal swamps, and leaving vast quantities of their remains in the shaly and even coaly beds formed in such places. Such were the pretty, graceful fishes of the genera

* *Climactichnites* and *Protichnites*.

Palæoniscus and *Amblypterus*. Pursuing and feeding on these were larger ganoids, armed with strong bony scales, and formidable conical or sharp-edged teeth. Of these were *Rhizodus* and *Acrolepis*. There were besides multitudes of sharks whose remains consist almost wholly of their teeth and spines, their cartilaginous skeletons having perished. One group was allied to the few species of modern sharks whose mouths are paved with flat teeth for crushing shells. These were the most abundant sharks of the Carboniferous—slow and greedy monsters, haunting shell banks and coral reefs, and grinding remorselessly all the shell-fishes that came in their way. There were also sharks furnished with sharp and trenchant teeth, which must have been the foes of the smaller mailed fishes, pursuing them into creeks and muddy shallows; and if we may judge from the quantity of their remains in some of these places, sometimes perishing in their eager efforts. On the whole, the fishes of the Carboniferous were, in regard to their general type, a continuation of those of the Devonian, but the sharks and the scaly ganoids were relatively more numerous. They differed from our modern fishes in the absence of the ordinary horny-scaled type to which all our more common fishes belong, and in the prevalence of that style of tail which has been termed “heterocercal,” in which the continuation of the backbone forms the upper lobe of the tail, a style which, if we may judge from modern examples, gives more power of upward and downward movement, and is especially

suitable to fishes which search for food only at the bottom, or only above the surface of the waters.

Most reluctantly I must here leave one of the most remarkable periods of the world's history, and reserve to our next chapter the summation of the history of the older world of life in its concluding stage, the Permian.

CHAPTER VII.

THE PERMIAN AGE AND CLOSE OF THE PALÆOZOIC.

THE immense swamps and low forest-clad plains which occupied the continental areas of the Northern Hemisphere, and which we now know extended also into the regions south of the equator, appear at the close of the Carboniferous age to have again sunk beneath the waves, or to have relapsed into the condition of sand and gravel banks; for a great thickness of such deposits rests on the coal measures and constitutes the upper coal formation, the upper "barren measures" of the coal-miners. There is something grand in the idea of this subsidence of a world of animal and vegetable life beneath the waters. The process was very slow,—so slow that at first vegetable growth and deposition of silt kept pace with it; and this is the reason of the immense series of deposits, in some places nearly 15,000 feet thick, which inclose or rest upon the coal beds; but at length it became more rapid, so that forests and their inhabitants perished, and the wild surf drifted sand and pebbles over their former abodes. So the Carboniferous world, like that of Noah, being overflowed with water, perished. But it was not a wicked world drowned for its sins, but merely an old and necessarily preliminary system, which had fully served its

purpose; and, like the stubble of last year, must be turned under by the plough that it may make way for a new verdure. The plough passed over it, and the winter of the Permian came, and then the spring of a new age.

The Permian and the succeeding Triassic are somewhat chilly and desolate periods of the earth's history. The one is the twilight of the Palæozoic day, the other is the dawn of the Mesozoic. Yet to the philosophical geologist no ages excel them in interest. They are times of transition, when old dynasties and races pass away and are replaced by new and vigorous successors, founding new empires and introducing new modes of life and action.

Three great leading points merit our attention in entering on the Permian age. The first is the earth-movements of the period. The second is the resulting mineral characteristics of the deposits formed. The third is the aspect of the animal and vegetable life of this age in their relation more especially to those which preceded.

With respect to the first point above named, the earth's crust was subjected in the Permian period to some of the grandest movements which have occurred in the whole course of geologic time, and we can fix the limits of these, in Europe and America at least, with some distinctness. If we examine the Permian rocks in England and Germany, we shall find that everywhere they lie on the upturned edges of the preceding Carboniferous beds. In other words, the

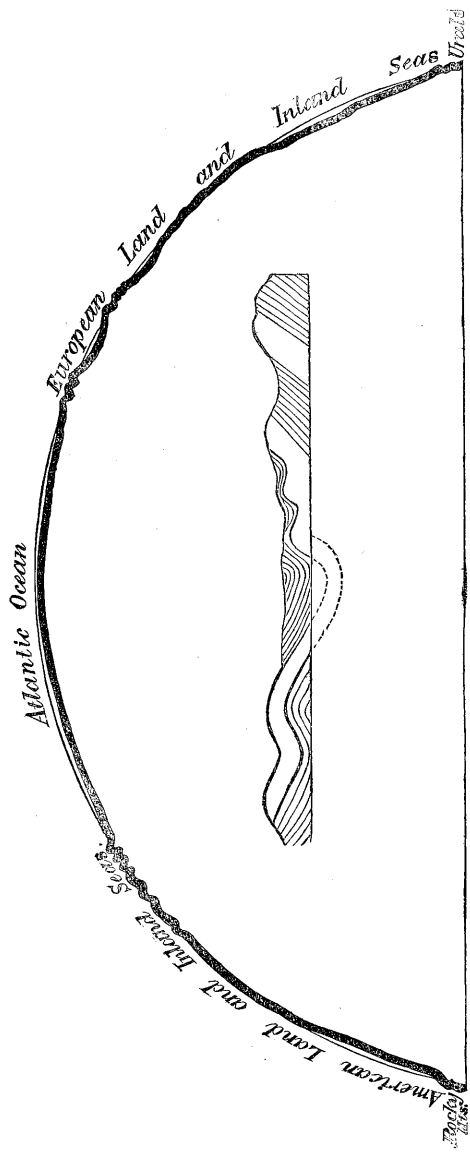


DIAGRAM OF FOLDINGS OF THE CRUST IN THE PERMIAN PERIOD.
 (The vertical scale of heights and depressions exaggerated more than six times.)
 The lower figure shows a portion of folded strata in the Appalachians—after Rogers.

latter have been thrown into a series of folds, and the tops of these folds have been more or less worn away before the Permian beds were placed on them. But if we pass on to the eastward, in the great plain between the Volga and the Ural mountains, where, in the "ancient kingdom of Perm," the greatest known area of these rocks is found, an area equal in extent to twice that of France, and which Sir R. I. Murchison, who first proposed the name, took as the typical district, we find, on the contrary, that the Permian and Carboniferous are conformable to one another. If now we cross the Atlantic and inquire how the case stands in America, we shall find it precisely the same. Here the great succession of earth-waves constituting the Appalachian Mountains rises abruptly at the eastern edge of the continent, and becomes flatter and flatter, until, in the broad plains west of the Mississippi, the Permian beds appear, as in Russia, resting upon the Carboniferous so quietly that it is not always easy to draw a line of separation between them. As Dana has remarked, we find at the western side of Europe and the eastern side of America, great disturbances inaugurating the Permian period; and in the interior of both, in the plains between the Volga and the Ural in one, and between the Mississippi and Rocky Mountains in the other, an entire absence of these disturbances. The main difference is, that in eastern America the whole Carboniferous areas have apparently been so raised up that no Permian was deposited on them, while in Europe considerable patches of the disturbed

areas became or remained submerged. Another American geologist has largely illustrated the fact that the movements which threw up the Appalachian folds were strongest to the eastward, and that the ridges of rock are steepest on their west sides, the force which caused them acting from the direction of the sea. It seems as if the Atlantic area had wanted elbow-room, and had crushed up the edges of the continents next to it. In other words, in the lapse of the Palæozoic ages the nucleus of the earth had shrunk away from its coating of rocky layers, which again collapsed into great wrinkles.

Such a process may seem difficult of comprehension. To understand it we must bear in mind some of its conditions. First, the amount of this wrinkling was extremely small relatively to the mass of the earth. In the diagram on page 162 it is greatly exaggerated, yet is seen to be quite insignificant, however gigantic in comparison with microscopic weaklings like ourselves. Secondly, it was probably extremely slow. Beds of solid rock cannot be suddenly bent into great folds without breaking, and the abruptness of some of the folds may be seen from our figure, copied from Rogers (page 162), of some of the foldings of the Appalachian Mountains. Thirdly, the older rocks below the Carboniferous and the Devonian must have been in a softened and plastic state, and so capable of filling up the vacancies left by the bending of the hard crust above. In evidence of this, we have in the Lower Permian immense volcanic ejections—lavas and other

molten rocks spewed out to the surface from the softened and molten masses below. Fourthly, the basin of the Atlantic must have been sufficiently strong to resist the immense lateral pressure, so that the yielding was all concentrated on the weaker parts of the crust near the old fractures at the margins of the great continents. In these places also, as we have seen in previous papers, the greatest thickness of deposits had been formed; so that there was great downward pressure, and probably, also, greater softening of the lower part of the crust. Fifthly, as suggested in a previous chapter, the folding of the earth's crust may have resulted from the continued shrinkage of its interior in consequence of cooling, leading after long intervals to collapse of the surface. Astronomers have, however, suggested another cause. The earth bulges at the equator, and is flattened at the poles in consequence of, or in connection with, the swiftness of its rotation; but it has been shown that the rotation of the earth is being very gradually lessened by the attraction of the moon.* Pierce has recently brought forward the idea † that this diminution of rotation, by causing the crust to subside in the equatorial regions and expand in the polar, might produce the movements observed; and which, according to Lesley, have amounted in the whole course of geological time to about two per cent. of the diameter of our globe. We

* Sir William Thomson, who quotes Adams and Delaunay.

† "Nature," February, 1871.

thus have two causes, either of which seems sufficient to produce the effect.

Viewed in this way, the great disturbances at the close of the Palæozoic period constitute one of the most instructive examples in the whole history of the earth of that process of collapse to which the crust was subject after long intervals, and of which no equally great instance occurs except at the close of the Laurentian and the close of the Mesozoic. The mineral peculiarities of the Permian are also accounted for by the above considerations. Let us now notice some of these. In nearly all parts of the world the Permian presents thick beds of red sandstone and conglomerate as marked ingredients. These, as we have already seen, are indications of rapid deposition accompanying changes of level. In the Permian, as elsewhere, these beds are accompanied by volcanic rocks, indicating the subterranean causes of the disturbances. Again, these rocks are chiefly abundant in those regions, like Western Europe, where the physical changes were at a maximum. Another remarkable feature of the Permian rocks is the occurrence of great beds of magnesian limestone, or dolomite. In England, the thick yellow magnesian limestone, the outcrop of which crosses in nearly a straight line through Durham, Yorkshire, and Nottingham, marks the edge of a great Permian sea extending far to the eastward. In the marls and sandstones of the Permian period there is also much gypsum. Now, chemistry shows us that magnesian limestones and gypsums are likely to

be deposited where sea water, which always contains salts of magnesia, is evaporating in limited or circumscribed areas into which carbonate of lime and carbonate of soda are being carried by streams from the land or springs from below;* and it is also to be observed that solutions of sulphuric acid, and probably also of sulphate of magnesia, are characteristic products of igneous activity. Hence we find in various geological periods magnesian limestones occurring as a deposit in limited shallow sea basins, and also in connection with volcanic breccias. Now these were obviously the new Permian conditions of what had once been the wide flat areas of the Carboniferous period. Still further, we find in Europe, as characteristic of this period, beds impregnated with metallic salts, especially of copper. Of this kind are very markedly the copper slates of Thuringia. Such beds are not, any more than magnesian limestones, limited to this age; but they are eminently characteristic of it. To produce them it is required that water should bring forth from the earth's crust large quantities of metallic salts, and that these should come into contact with vegetable matters in limited submerged areas, so that sulphates of the metals should be deoxidized into sulphides. A somewhat different chemical process, as already explained, was very active in the coal period, and was connected with the production of its iron ores; but, in the Permian, profound and extensive fractures opened up the way to the deep seats of copper and

* Hunt, "Silliman's Journal," 1859 and 1866.

other metals, to enrich the copper slate and its associated beds. It is also to be observed that the alkaline springs and waters which contain carbonate of soda, very frequently hold various metallic salts; so that where, owing to the action of such waters, magnesian limestone is being deposited, we may expect also to find various metallic ores.

Let us sum up shortly this history. We have foldings of the earth's crust, causing volcanic action and producing limited and shallow sea-basins, and at the same time causing the evolution of alkaline and metalliferous springs. The union of these mechanical and chemical causes explains at once the conglomerates, the red sandstones, the trap rocks, the magnesian limestones, the gypsum, and the metalliferous beds of the Permian. The same considerations explain the occurrence of similar deposits in various other ages of the earth's history; though, perhaps, in none of these were they so general over the Northern Hemisphere as in the Permian.

From the size of the stones in some of the Permian conglomerates, and their scratched surfaces, it has been supposed that there were in this period, on the margins of the continents, mountains sufficiently high to have snow-clad summits, and to send down glaciers, bearing rocks and stones to the sea, on which may have floated, as now in the North Atlantic, huge icebergs.* This would be quite in accordance with the

* Ramsay has ably illustrated this in the Permian conglomerates of England.

great elevation of land which we know actually occurred; and the existence of snow-clad mountains along with volcanoes would be a union of fire and frost of which we still have examples in some parts of the earth's surface, and this in proximity to forms of vegetable life very similiar to those which we know existed in the Permian.

With the exception of a few small and worthless beds in Russia, the Permian is not known to contain any coal. The great swamps of the coal period had disappeared. In part they were raised up into rugged mountains. In part they were sunken into shallow sea areas. Thus, while there was much dry land, there was little opportunity for coal production, or for the existence of those rank forests which had accumulated so much vegetable matter in the Carboniferous age. In like manner the fauna of the Permian waters is poor. According to Murchison, the Permian limestones of Europe have afforded little more than one-third as many species of fossils as the older Carboniferous. The fossils themselves also have a stunted and depauperated aspect, indicating conditions of existence unfavourable to them. This is curiously seen in contrasting Davidson's beautiful illustrations of the British Lamp-shells of the Permian and Carboniferous periods. Another illustrative fact is the exceptionally small size of the fossils even in limestones of the Carboniferous period when these are associated with gypsum, red sandstones, and magnesian minerals; as, for instance, those of some parts of

Nova Scotia. In truth, the peculiar chemical conditions conducive to the production of magnesian limestones and gypsum are not favourable to animal life, though no doubt compatible with its existence. Hence the rich fauna of the Carboniferous seas died out in the Permian, and was not renewed; and the Atlantic areas of the period are unknown to us. They were, however, probably very deep and abrupt in slope, and not rich in life. This would be especially the case if they were desolated by cold ice-laden currents.

During the Permian period there was in each of our continental areas a somewhat extensive inland sea. That of Western America was a northward extension of the Gulf of Mexico. That of Eastern Europe was a northward extension of the Euxine and Caspian. In both, the deposits formed were very similar—magnesian limestones, sandstones, conglomerates, marls, and gypsums. In both, these alternate in such a way as to show that there were frequent oscillations of level, producing alternately shallow and deep waters. In both, the animal remains are of similar species, in many instances even identical. But in the areas intervening between these sea basins and the Atlantic the conditions were somewhat different. In Europe the land was interrupted by considerable water areas, not lakes, but inland sea basins; sometimes probably connected with the open sea, sometimes isolated. In these were deposited the magnesian limestone and its associated beds in England, and the Zechstein and Rotheliegende with their associates in Germany. In

America the case was different. In all that immense area which extends from the Atlantic to the plains east of the Mississippi, we know no Permian rocks, unless a portion of those reckoned as Upper Carboniferous, or Permo-carboniferous in Northern Nova Scotia, and Prince Edward Island, should be included in this group. If such existed, they may possibly be covered up in some places by more modern deposits, or may have been swept away by denudation in the intervening ages; but even in these cases we should expect to find some visible remains of them. Their entire absence would seem to indicate that a vast, and in many parts rugged and elevated, continent represented North America in the Permian period. Yet if so, that great continent is an absolute blank to us. We know nothing of the animals or plants which may have lived on it, nor do we even know with certainty that it had active volcanoes, or snow-clad mountains sending down glaciers.

Our picture of the Permian World has not been inviting, yet in many respects it was a world more like that in which we live than was any previous one. It certainly presented more of variety and grand physical features than any of the previous ages; and we might have expected that on its wide and varied continents some new and higher forms of life would have been introduced. But it seems rather to have been intended to blot out the old Palæozoic life, as an arrangement which had been fully tried and served its end, preparatory to a new beginning in the succeeding age.

Still the Permian has some life features of its own, and we must now turn to these. The first is the occurrence here, not only of the representatives of the great Batrachians of the coal period, but of true reptiles, acknowledged to be such by all naturalists. The animals of the genus *Protorosaurus*, found in rocks of this age both in England and Germany, were highly-organised lizards, having socketed teeth like those of crocodiles, and well-developed limbs, with long tails, perhaps adapted for swimming. They have, however, biconcave vertebræ like the lizard-like animals of the coal already mentioned, which, indeed, in their general form and appearance, they must have very closely resembled. The Protorosaurs were not of great size; but they must have been creatures of more stately gait than their Carboniferous predecessors, and they serve to connect them with the new and greater reptiles of the next period.

Another interesting feature of the Permian is its flora, which, in so far as known, is closely related to that of the coal period, though the species are regarded as different; some of the forms, however, being so similar as to be possibly identical. In a picture of the Permian flora we should perhaps place in the foreground the tree-ferns, which seem to have been very abundant, and furnished with dense clusters of aerial roots to enable them to withstand the storms of this boisterous age. The tree-ferns, now so plentiful in the southern hemisphere, should be regarded as one of the permanent vegetable institutions of our world—those

of the far-back Lower Devonian, and of all intervening ages up to the present day, having been very much alike. The great reed-like *Calamites* have had a different fate. In their grander forms they make their last appearance in the Permian, where they culminate in great ribbed stems, sometimes nearly a foot in diameter, and probably of immense height. The brakes of these huge mares'-tails which overspread the lower levels of the Permian in Europe, would have been to us what the hayfields of Brobdingnag were to Gulliver. The *Lepidodendra* also swarmed, though in diminished force; but the great *Sigillariæ* of the coal are absent, or only doubtfully present. Another feature of the Permian woods was the presence of many pine-trees different in aspect from those of the coal period. Some of these are remarkable for their slender and delicate branches and foliage.* Others have more dense and scaly leaves, and thick short cones.† Both of these styles of pines are regarded as distinct, on the one hand, from those of the coal formation, and on the other from those of the succeeding Trias. I have shown, however, many years ago, that in the upper coal formation of America there are branches of pine-trees very similar to *Walchia*, and, on the other hand, the Permian pines are not very remote in form and structure from some of their modern relations. The pines of the first of the above-mentioned types (*Walchia*) may indeed be regarded as allies of the modern Araucarian pines of the southern hemisphere,

* *Walchia*.† *Ulmannia*.

and of the old conifers of the Carboniferous. Those of the second type (*Ulmannia*) may be referred to the same group with the magnificent Sequoias or Redwoods of California.

It is a curious indication of the doubts which sometimes rest on fossil botany, that some of the branches of these Permian pines, when imperfectly preserved, have been described as sea-weeds, while others have been regarded as club-mosses. It is true, however, that the resemblance of some of them to the latter class of plants is very great; and were there no older pines, we might be pardoned for imagining in the Permian a transition from club-mosses to pines. Unfortunately, however, we have pines nearly as far back in geological time as we have club-mosses; and, in so far as we know, no more like the latter than are the pines of the Permian, so that this connection fails us. In all probability the Permian forests are much less perfectly known to us than those of the coal period, so that we can scarcely make comparisons. It appears certain, however, that the Permian plants are much more closely related to the coal plants than to those of the next succeeding epoch, and that they are not so much a transition from the one to the other as the finishing of the older period to make way for the newer.

But we must reserve some space for a few remarks on the progress and termination of the Palæozoic as a whole, and on the place which it occupies in the world's history. These remarks we may group around the central question, What is the meaning or value of

an age or period in the history of the earth, as these terms are understood by geologists? In most geological books terms referring to time are employed very loosely. Period, epoch, age, system, series, formation, and similar terms, are used or abused in a manner which only the indefiniteness of our conceptions can excuse.

A great American geologist* has made an attempt to remedy this by attaching definite values to such words as those above mentioned. In his system the greater divisions of the history were "Times:" thus the Eozoic was a time and the Palæozoic was a time. The larger divisions of the times are "Ages:" thus the Lower and Upper Silurian, the Devonian, and the Carboniferous are ages, which are equivalent in the main to what English geologists call Systems of Formations. Ages, again, may be divided into "Periods:" thus, in the Upper Silurian, the Ludlow of England, or Lower Helderberg of America, would constitute a period. These periods may again be divided into "Epochs," which are equivalent to what English geologists call Formations, a term referring not directly to the time elapsed, but to the work done in it. Now this mode of regarding geological time introduces many thoughts as to the nature of our chronology and matters relating to it. A "time" in geology is an extremely long time, and the Palæozoic was perhaps the longest of the whole. By the close of the Palæozoic nine-tenths of all the rocks we know

* Dana.

in the earth's crust were formed. At least this is the case if we reckon mere thickness. For aught that we know, the Eozoic time may have accumulated as much rock as the Palæozoic; but leaving this out of the question, the rocks of the Palæozoic are vastly thicker than those of the Mesozoic and Cainozoic united. Thus the earth's history seems to have dragged slowly in its earlier stages, or to have become accelerated in its latter times. To place it in another point of view, life changes were greater relatively to merely physical changes in the later than in the earlier times.

The same law seems to have obtained within the Palæozoic time itself. Its older periods, as the Cambrian and Lower Silurian, present immense thicknesses of rock with little changes in life. Its later periods, the Carboniferous and Permian, have greater life-revolution relatively to less thickness of deposits. This again was evidently related to the growing complexity and variety of geographical conditions, which went on increasing all the way up to the Permian, when they attained their maximum for the Palæozoic time.

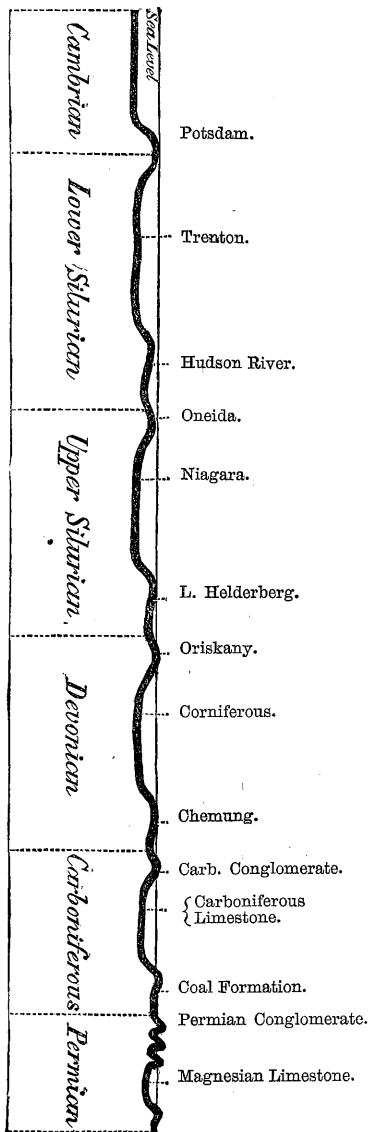
Again, each age was signalized, over the two great continental plateaus, by a like series of elevations and depressions. We may regard the Siluro-Cambrian, the Silurian, the Devonian, the Carboniferous, and Permian, as each of them a distinct age. Each of these began with physical disturbances and coarse shallow-water deposits. In each this was succeeded by sub-

sidence and by a sea area tenanted by corals and shell-fishes. In each case this was followed by a re-elevation, leading to a second but slow and partial subsidence, to be followed by the great re-elevation preparatory to the next period. Thus we have throughout the Palæozoic a series of cycles of physical change which we may liken to gigantic pulsations of the thick hide of mother earth. The final catastrophe of the Permian collapse was quite different in kind from these pulsations as well as much greater in degree. The Cambrian or Primordial does not apparently present a perfect cycle of this kind, perhaps because in that early period the continental plateaus were not yet definitely formed, and thus its beds are rather portions of the general oceanic deposit. In this respect it is analogous in geological relations to the chalk formation of a later age, though very different in material. The Cambrian may, however, yet vindicate its claim to be regarded as a definite cycle; and the recent discoveries of Hicks in North Wales, have proved the existence of a rich marine fauna far down in the lower part of this system. It is also to be observed that the peculiar character of the Cambrian, as an oceanic bottom rather than a continental plateau, has formed an important element in the difficulties in establishing it as a distinct group; just as a similar difficulty in the case of the chalk has led to a recent controversy about the continuance of the conditions of that period into modern times.

But in each of the great successive heaves or pulsations of the Palæozoic earth, there was a growing balance in favour of the land as compared with the water. In each successive movement more and more elevated land was thrown up, until the Permian flexures finally fixed the forms of our continents. This may be made evident to the eye in a series of curves, as in the following diagram, in which I have endeavoured to show the recurrence of similar conditions in each of the great periods of the Palæozoic, and thus their equivalency to each other as cycles of the earth's history.

There is thus in these great continental changes a law of recurrence and a law of progress; but as to the efficient causes of the phenomena we have as yet little information. It seems that original fractures and shrinkages of the crust were concerned in forming the continental areas at first. Once formed, unequal burdening of the earth's still plastic mass by deposits of sediment in the waters, and unequal expansion by the heating and crystallization of immense thicknesses of the sediment, may have done the rest; but the results are surprisingly regular to be produced by such causes. We shall also find that similar cycles can be observed in the geological ages which succeeded the Palæozoic. Geologists have hitherto for the most part been content to assign these movements to causes purely terrestrial; but it is difficult to avoid the suspicion that the succession of geological cycles must have depended on some recurring astronomical force

CURVES SHOWING THE SUCCESSIVE ELEVATIONS AND DEPRESSIONS OF THE AMERICAN CONTINENT, IN THE SEVERAL CYCLES OF THE PALEOZOIC TIME.



tending to cause the weaker parts of the earth's crust alternately to rise and subside at regular intervals of time. Herschel, Adhémar, and more recently Croll, have directed attention to astronomical cycles supposed to have important influences on the temperature of the earth. Whether these or other changes may have acted on the equilibrium of its crust is a question well worthy of attention, as its solution might give us an astronomical measure of geological time. This question, however, the geologist must refer to the astronomer.

There are two notes of caution which must here be given to the reader. First, it is not intended to apply the doctrine of continental oscillations to the great oceanic areas. Whether they became shallower or deeper, their conditions would be different from those which occurred in the great shallow plateaus, and these conditions are little known to us. Further, throughout the Palæozoic period, the oscillations do not seem to have been sufficient to reverse the positions of the oceans and continents. Secondly, it is not meant to affirm that the great Permian plications were so widespread in their effects as to produce a universal destruction of life. On the contrary, after they had occurred, remnants of the Carboniferous fauna still flourished even on the surfaces of the continents, and possibly the inhabitants of the deep ocean were little affected by these great movements. True it is that the life of the Palæozoic terminates with the Permian, but not by a great and cataclysmic overthrow.

We know something at least of the general laws of

continental oscillations during the Palæozoic. Do we know anything of law in the case of life? The question raises so many and diverse considerations that it seems vain to treat it in the end of a chapter; still we must try to outline it with at least a few touches.

First, then, the life of the Palæozoic was remarkable, as compared with that of the present world, in presenting a great prevalence of animals and plants of synthetic types, as they are called by Agassiz—that is, of creatures comprehending in one the properties of several groups which were to exist as distinct in the future. Such types are also sometimes called embryonic, because the young of animals and plants often show these comprehensive features. Such types were the old corals, presenting points of alliance with two distinct groups now widely separated; the old Trilobites, half king-crabs and half Isopods; the Amphibians of the coal, part fish, part newt, and part crocodile; the Sigillariæ, part club-mosses and part pines; the Orthoceratites, half nautili and half cuttle-fishes. I proposed, in the illustration in a former article, to give a restoration of one of the curious creatures last mentioned, the Orthoceratites; but on attempting this, with the idea that, as usually supposed, they were straight Nautili, it appeared that the narrow aperture, the small outer chamber, the thin outer wall, often apparently only membranous, and the large siphuncle, would scarcely admit of this; and I finished by representing it as something like a modern squid; perhaps wrongly, but it was evidently somewhere between them and the Nautili.

Secondly, these synthetic types often belonged to the upper part of a lower group, or to the lower part of an upper group. Hence in one point of view they may be regarded as of high grade, in another as of low grade, and they are often large in size or in vegetative development.* From this law have arisen many controversies about the grade and classification of the Palæozoic animals and plants.

Thirdly, extinctions of species occur in every great oscillation of the continental areas, but some species reappear after such oscillations, and the same genus often recurs under new specific forms. Families and orders, such as those of the Trilobites and Orthoceratites, appear to have a grand and gradual culmination and decadence extending over several successive periods, or even over the whole stretch of the Palæozoic time. Toward the close of the Palæozoic, while all the species disappear, some whole families and orders are altogether dropped, and, being chiefly synthetic groups, are replaced by more specialised types, some of which, however, make small beginnings alongside of the more general types which are passing away. Our diagram (page 183) illustrates these points.

Fourthly, the progress in animal life in the Palæozoic related chiefly to the lower or invertebrate tribes, and

* It seems, indeed, as if the new synthetic forms intermediate between great groups were often large in size, while the new special types came in as small species. There are some remarkable cases of this in the plant world; though here we have such examples as the pines and tree-ferns continuing almost unchanged from an early Palæozoic period until now.

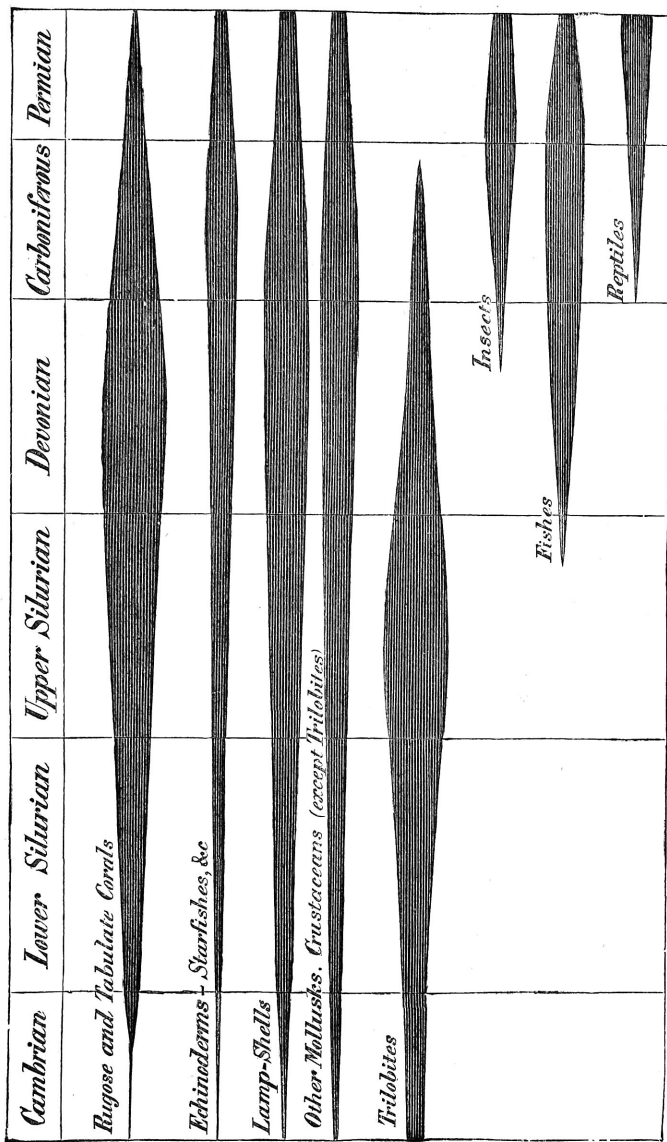


DIAGRAM SHOWING THE ADVANCE, CULMINATION, AND DECADENCE OF SOME OF THE LEADING TYPES OF PALÆOZOIC LIFE.

to the two lower classes of the vertebrates. The oldest animal known to us is not only a creature of the simplest structure, but also a representative of that great and on the whole low type of animal life, in which the parts are arranged around a central axis, and not on that plan of bilateral symmetry which constitutes one great leading distinction of the higher animals. With the Cambrian, bilateral animals abound and belong to two very distinct lines of progress—the one, the Mollusks, showing the nutritive organs more fully developed—the other, the Articulates, having the organs of sense and of locomotion more fully organized. These three great types shared the world among them throughout the earlier Palæozoic time, and only in its later ages began to be dominated by the higher types of fishes and reptiles. In so far as we know, it remained for the Mesozoic to introduce the birds and mammals. In plant life the changes were less marked, though here also there is progress—land plants appear to begin, not with the lowest forms, but with the highest types of the lower of the two great series into which the vegetable kingdom is divided. From this they rapidly rise to a full development of the lowest type of the flowering plants, the pines and their allies, and there the progress ceases; for the known representatives of the higher plants are extremely few and apparently of little importance.

Fifthly, in general the history tells of a continued series of alternate victories and defeats of the species that had their birth on the land and in the shallow

waters, and those which were born in the ocean depths. The former spread themselves widely after every upheaval, and then by every subsidence were driven back to their mountain fastnesses. The latter perished from the continental plateaus at every upheaval, but climbed again in new hordes and reoccupied the ground after every subsidence. But just as in human history every victory or defeat urges on the progress of events, and develops the great plan of God's providence in the elevation of man; so here every succeeding change brings in new and higher actors on the stage, and the scheme of creation moves on in a grand and steady progress towards the more varied and elevated life of the Modern World.

But, after all, how little do we know of these laws, which are only beginning to dawn on the minds of naturalists; and which the imperfections of our classification and nomenclature, and the defects in our knowledge of fossil species, render very dim and uncertain. All that appears settled is the existence of a definite plan, working over long ages, and connected with the most remarkable correlation of physical and organic change: going on with regular march throughout the Palæozoic, and then brought to a close to make room for another great succession. This following Mesozoic time must next engage our attention.

We may close for the present with presenting to the eye in tabular form the periods over which we have passed. The table on page 187, and the diagram (page 179), mutually illustrate each other;

and it will be seen that each age constitutes a cycle, similar in its leading features to the other cycles, while each is distinguished by some important fact in relation to the introduction of living beings. In this table I have, with Mr. Hull,* for simplicity, arranged the formations of each age under three periods—an older, middle, and newer. Of these, however, the last or newest is in each case so important and varied as to merit division into two, in the manner which I have suggested in previous publications for the Palæozoic rocks of North America.† Under each period I have endeavoured to give some characteristic example from Europe and America, except where, as in the case of the coal formation, the same names are used on both continents. Such a table as this, it must be observed, is only tentative, and may admit of important modifications. The Laurentian more especially may admit of division into several ages; and a separate age may be found to intervene between it and the Cambrian. The reader will please observe that this table refers to the changes on the continental plateaus; and that on both of these each age was introduced with shallow water and usually coarse deposits, succeeded by deeper water and finer beds, usually limestones, and these by a mixed formation returning to the shallow water and coarse deposits of the older period of the age. This last kind of deposition culminates in the great swamps of the coal formation.

* "Quarterly Journal of Science," July, 1869.

† "Acadian Geology," p. 137.

CONDENSED TABULAR VIEW OF THE AGES AND PERIODS OF THE PALÆOZOIC AND Eozoic.

TIMES.	AGES.	PERIODS.	ANIMALS AND PLANTS.	
PALÆOZOIC.	PERMIAN	Newer. Red Sandstones, Rauchwacke, etc. Middle. Zechstein, or Magnesian Limestone. Older. Conglomerates, etc., Rothelegendes.	Beginning of Age of Reptiles. Ages of Aevogens and Gymnosperms. And God said, "Let the waters bring forth abundantly the swarming living creatures." created great reptiles.	
	CARBONIFEROUS	N. Coal Formation. M. Carboniferous Limestone. O. Lower Coal Measures and Conglomerates.	Age of Batrachians.	
	DEVONIAN OR ERLIAN	N. Upper Old Red, Chemung. M. Eifel and Corniferous Limestones. O. Lower Old Red, Oriskany Sandstone.	Age of Fishes.	
	UPPER SILURIAN ...	N. Indlow, Lower Helderberg. M. Wenlock and Niagara Limestones. O. Mayhill, etc., Oneida Conglomerates.	Age of Mollusks.	
	LOWER SILURIAN, OR SILURO-CAMBIAN	N. Caradoc, Hudson R. M. Bala and Trenton Limestones. O. Liandello, etc., Chazy.	Tabulate and Rugose Corals, abundant.	
	CAMBIAN	N. Lingula Flags, etc., Potsdam Sandstone. M. (Uncertain) } Acadian, etc. ? O. Longmynd, Huronian ? } Menevian ?	Ages of Algae.	
	LAURENTIAN	N. Anorthosite Gneiss, etc. M. Eozoon Limestones, etc. O. Lower Gneiss.	Age of Crustaceans. Age of Protozoa.	
	Eozoic.			

CHAPTER VIII.

THE MESOZOIC AGES.

PHYSICALLY, the transition from the Permian to the Trias is easy. In the domain of life a great gulf lies between; and the geologist whose mind is filled with the forms of the Palæozoic period, on rising into the next succeeding beds, feels himself a sort of Rip Van Winkle, who has slept a hundred years and awakes in a new world. The geography of our continents seems indeed to have changed little from the time of the Permian to that next succeeding group which all geologists recognise as the beginning of the Mesozoic or Middle Age of the world's history, the Triassic period. Where best developed, as in Germany, it gives us the usual threefold series, conglomerates and sandstones below, a shelly limestone in the middle, and sandstones and marls above. Curiously enough, the Germans, recognising this tripartite character here more distinctly than in their other formations, named this the *Trias* or triple group, a name which it still retains, though as we have seen it is by no means the earliest of the triple groups of strata. In England, where the middle limestone is absent, it is a "New Red Sandstone," and the same name may be appropriately extended to Eastern America, where bright red sandstones are a charac-

teristic feature. In the Trias, as in the Permian, the continents of the northern hemisphere presented large land areas, and there were lagoons and land-locked seas in which gypsum, magnesian limestones, and rock salt were thrown down, a very eminent example of which is afforded by the great salt deposits of Cheshire. There were also tremendous outbursts of igneous activity along the margins of the continents, more especially in Eastern America. But with all this there was a rich land flora and a wonderful exuberance of new animal life on the land; and in places there were even swamps in which pure and valuable beds of coal, comparable with those of the old coal formation, were deposited.

The triple division of the Trias as a cycle of the earth's history, and its local imperfection, are well seen in the European development of the group, thus:—

German Series.	French Series.	English Series.
Keuper, Sandstone and Shale	Marnes Irisées	} Saliferous and gypsiferous Shales and Sandstones.
Muschelkalk, Limestone and Dolomite }	Calcaire Coquillier }	
Bunter, Sandstone and Conglomerate	Grès bigarré	Wanting.
		} Sandstone and Conglomerate.

The Trias is succeeded by a great and complex system of formations, usually known as the Jurassic, from its admirable development and exposure in the

range of the Jura; but which the English geologists often name the "Oolitic," from the occurrence in it of beds of Oolite or roe-stone. This rock, of which the beautiful cream-coloured limestone of Bath is an illustration, consists of an infinity of little spheres, like seeds or the roe of a fish. Under the microscope these are seen to present concentric layers, each with a radiating fibrous structure, and often to have a minute grain of sand or fragment of shell in the centre. They are, in short, miniature concretions, produced by the aggregation of the calcareous matter around centres, by a process of molecular attraction to which fine sediments, and especially those containing much lime, are very prone. This style of limestone is very abundant in the Jurassic system, but it is not confined to it. I have seen very perfect Oolites in the Silurian and the Carboniferous. The Jurassic series, as developed in England, may be divided into three triplets or cycles of beds, in the following way:—

Upper Jurassic	{ Purbeck Beds. Portland Limestone. Portland Sand.
Middle Jurassic	{ Kimmeridge Clay, etc. Coral Rag, Limestone. Lower Calcareous Grit, Oxford Clay, etc.
Lower Jurassic* ...	{ Cornbrash and Forest Marble. Great and inferior Oolite, Limestone. Lias Clays and Limestones.

These rocks occupy a large space in England, as

* This last group is very complex, and might perhaps admit of subdivision, locally at least, into subordinate cycles.

the names above given will serve to show; and they are also largely distributed over the continent of Europe and Asia—which had evidently three great and long-continued dips under water, indicated by the three great limestones. In America the case was different. The Jurassic has not been distinctly recognised in any part of the eastern coast of that continent, which then perhaps extended farther into the Atlantic than it does at present; so that no marine beds were formed on its eastern border. But in the west, along the base of the Rocky Mountains and also in the Arctic area, there were Jurassic seas of large extent, swarming with characteristic animals. At the close of the Jurassic period our continents seem to have been even more extensive than at present. In England and the neighbouring parts of the continent of Europe, according to Lyell, the freshwater and estuarine beds known as the Wealden have been traced 320 miles from west to east, and 200 miles from north-west to south-east, and their thickness in one part of this area is estimated at no less than 2,000 feet. Such a deposit is comparable in extent with the deltas of such great rivers as the Niger or even the Mississippi, and implies the existence of a continent much more extensive and more uniform in drainage than Europe as it at present exists. Lyell even speculates on the possible existence of an Atlantic continent west of Europe. America also at this time had, as already stated, attained to even more than its present extension

eastwards. Thus this later Jurassic period was the culmination of the Mesozoic, the period of its most perfect continental development, corresponding in this to the Carboniferous in the Palæozoic.

The next or closing period of this great Mesozoic time brought a wondrous change. In the Cretaceous period, so called from the vast deposits of chalk by which it is characterized, the continents sunk as they had never sunk before, so that vast spaces of the great continental plateaus were brought down, for the first time since the Laurentian, to the condition of abyssal depths, tenanted by such creatures as live in the deepest recesses of our modern oceans. This great depression affected Europe more severely than America; the depression of the latter being not only less, but somewhat later in date. In Europe, at the period of greatest submergence, the hills of Scandinavia and of Britain, and the Urals, perhaps alone stood out of the sea. The Alps and their related mountains, and even the Himalayas, were not yet born, for they have on their high summits deep-sea beds of the Cretaceous and even of later date. In America, the Appalachians and the old Laurentian ranges remained above water; but the Rocky Mountains and the Andes were in great part submerged, and a great Cretaceous sea extended from the Appalachians westward to the Pacific, and southward to the Gulf of Mexico, opening probably to the North into the Arctic Ocean.

This great depression must have been of very long continuance, since in Western Europe it sufficed for

the production of nearly 1,000 feet in thickness of chalk, a rock which, being composed almost entirely of microscopic shells, is, as we shall see in the sequel, necessarily of extremely slow growth. If we regard the Cretaceous group as one of our great ages or cycles, it seems to be incomplete. The sandstones and clays known as the Greensand and Gault constitute its lower or shallow-water member. The chalk is its middle or deep-sea member, but the upper shallow-water member is missing, or only very locally and imperfectly developed. And the oldest of the succeeding Tertiary deposits, which indicate much less continuous marine conditions, rest on the chalk, as if the great and deep sea of the Cretaceous age had been suddenly upheaved into land. This abrupt termination of the last cycle of the Mesozoic is obviously the reason of the otherwise inexplicable fact that the prevalent life of the period ceases at the top of the chalk, and is exchanged immediately and without any transition for the very different fauna of the Tertiary. This further accords with the fact that the Cretaceous subsidence ended in another great crumpling of the crust, like that which distinguished the Permian. By this the Mesozoic time was terminated and the Cainozoic inaugurated; while the Rocky Mountains, the Andes, the Alps, and the Himalayas, rose to importance as great mountain ranges, and the continents were again braced up to retain a condition of comparative equilibrium during that later period of the earth's chronology to which we ourselves belong.



LIFE ON THE LAND IN THE MESOZOIC PERIOD.

In the foreground are a Pine, Cycads, and a *Fandanus*; also small mammals, an Ichthyosaurus, Dinosaur, and a *Lehrinthodont*. In the distance are other Dinosaurs and Crocodiles. In the air are birds (*Archaeopteryx*) and Pterodactyls.

Was the length of the Mesozoic time equal to that of the Palæozoic? Measured by recurring cycles it was. In the latter period we find five great cycles, from the Lower Silurian to the Permian inclusive. So in the Mesozoic we have five also, from the Trias to the Cretaceous inclusive. We have a right to reckon these cycles as ages or great years of the earth; and so reckoning them, the Mesozoic time may have been as long as the Palæozoic. But if we take another criterion the result will be different. The thickness of the deposits in the Palæozoic as compared with the Mesozoic, where these are severally best developed, may be estimated as at least four or five to one; so that if we suppose the beds to have been formed with equal rapidity in the two great periods, then the older of the two was between four and five times as long as the latter, which would indeed be only a little greater than one of the separate ages of the Palæozoic. Either, therefore, the deposits took place with greater rapidity in the Palæozoic, or that period was by much the longer of the two. This, it will be observed, is only another aspect of the great laws of geological sequence referred to in our last paper.

Let us look into this question a little more minutely. If the several pulsations of our continents depended upon any regularly recurring astronomical or terrestrial change, then they must represent, at least approximately, equal portions of time, and this, if proved, would settle the question in favour of an

equal duration of these two great eras of the earth's history. But as we cannot yet prove this, we may consider what light we can derive from the nature of the rocks produced. These may be roughly classified as of two kinds: First, the beds of sediment, sand, clay, etc., accumulated by the slow chemical decay of rocks and the mechanical agency of water. Secondly, the beds formed by accumulation of the harder and less perishable parts of living beings, of which the limestones are the chief. With reference to the first of these kinds of deposit, the action of the atmosphere and rains on rocks in the earlier times might have been somewhat more powerful if there was more carbonic acid in the atmosphere, that substance being the most efficient agent in the chemical decay of rocks. It might have been somewhat more powerful if there was a greater rainfall. It must, on the other hand, have been lessened by the apparently more equable temperature which then prevailed. These differences might perhaps nearly balance one another. Then the rocks of the older time were quite as intractable as those of the newer, and they were probably neither so high nor so extensive. Further, the dips and emergences of the great continental plateaus were equally numerous in the two great periods, though they were probably, with the exception of the latest one of each, more complete in the older period. In so far, then, as deposition of sediment is concerned, these considerations would scarcely lead us to infer that it was more rapid in the Palæozoic. But the Palæozoic sediments

may be estimated in the aggregate at about 50,000 feet in thickness, while those of the Mesozoic scarcely reach 8,000. We might, therefore, infer that the Palæozoic period was perhaps five or six times as long as the Mesozoic.

If we take the second class of rocks, the limestones, and suppose these to have been accumulated by the slow growth of corals, shells, etc., in the sea, we might, at first sight, suppose that Palæozoic animals would not grow or accumulate limestone faster than their Mesozoic successors. We must, however, consider here the probability that the older oceans contained more lime in solution than those which now exist, and that the equable temperature and extensive submerged plateaus gave very favourable conditions for the lower animals of the sea, so that it would perhaps be fair to allow a somewhat more rapid rate of growth of limestone for the Palæozoic. Now the actual proportions of limestone may be roughly stated at 13,000 feet in the Palæozoic, and 3,000 feet in the Mesozoic, which would give a proportion of about four and a quarter to one; and as a foot of limestone may be supposed on the average to require five times as long for its formation as a foot of sediment, this would give an even greater absolute excess in favour of the Palæozoic on the evidence of the limestones—an excess probably far too great to be accounted for by any more favourable conditions for the secretion of carbonate of lime by marine animals.

The data for such calculations are very uncertain; and three elements of additional uncertainty closely related to each other must also be noticed. The first is the unknown length of the intervals in which no deposition whatever may have been taking place over the areas open to our investigation. The second is the varying amounts in which material once deposited may have been swept away by water. The third is the amount of difference that may have resulted from the progressive change of the geographical features of our continents. These uncertainties would all tend to diminish our estimate of the relative length of the Mesozoic. Lastly, the changes that have taken place in living beings, though a good measure of the lapse of time, cannot be taken as a criterion here, since there is much reason to believe that more rapid changes of physical conditions act as an inducing cause of rapid changes of life.

On the whole, then, taking such facts as we have, and making large deductions for the several causes tending to exaggerate our conception of Palæozoic time, we can scarcely doubt that the Palæozoic may have been three times as long as the Mesozoic. If so, the continental pulsations, and the changes in animal and vegetable life, must have gone on with accelerated rapidity in the later period,—a conclusion to which we shall again have occasion to refer when we arrive at the consideration of the Tertiary or Neozoic time, and the age of man, and the probable duration of the order of things under which we live.

I have given this preliminary sketch of the whole Mesozoic time, because we cannot here, as in the Palæozoic, take up each age separately; and now we must try to picture to ourselves the life and action of these ages. In doing so we may look at, first, the plant life of this period; second, animal life on the land; and third, animal life in the waters and in the ocean depths.

The Mesozoic shores were clothed with an abundant flora, which changed considerably in its form during the lapse of this long time; but yet it has a character of its own distinct from that of the previous Palæozoic and the succeeding Tertiary. Perhaps no feature of this period is more characteristic than the great abundance of those singular plants, the cycads, which in the modern flora are placed near to the pines, but in their appearance and habit more resemble palms, and which in the modern world are chiefly found in the tropical and warm temperate zones of Asia and America. No plants certainly of this order occur in the Carboniferous, where their nearest allies are perhaps some of the *Sigillariæ*; and in the modern time the cycads are not so abundant, nor do they occur at all in climates where their predecessors appear to have abounded. In the quarries of the island of Portland, we have a remarkable evidence of this in beds with numerous stems of cycads still *in situ* in the soil in which they grew, and associated with stumps of pines which seem to have flourished along with them. In further illustra-

tion of this point, I may refer to the fact that Caruthers, in a recent paper, catalogues twenty-five British species belonging to eight genera—a fact which markedly characterizes the British flora of the Mesozoic period. These plants will therefore occupy a prominent place in our restoration of the Mesozoic landscape, and we should give especial prominence to the beautiful species *Williamsonia gigas*, discovered by the eminent botanist whose name it bears, and restored in his paper on the plant in the “*Linnaean Transactions*.” These plants, with pines and gigantic equisetums, prevailed greatly in the earlier Mesozoic flora, but as the time wore on, various kinds of endogens, resembling the palms and the screw-pines of the tropical islands, were introduced, and toward its close some representatives of the exogens very like our ordinary trees. Among these we find for the first time in our upward progress in the history of the earth, species of our familiar oaks, figs, and walnut, along with some trees now confined to Australia and the Cape of Good Hope, as the banksias and “silver-trees,” and their allies. In America a large number of the genera of the modern trees are present, and even some of those now peculiar to America, as the tulip-trees and sweet-gums. These forests of the later Mesozoic must therefore have been as gay with flowers and as beautiful in foliage as those of the modern world, and there is evidence that they swarmed with insect life. Further, the Mesozoic plants produced in some places beds of coal

comparable in value and thickness to those of the old coal formation. Of this kind are the coal beds of Brora in Sutherlandshire, those of Richmond in Virginia, and Deep River in N. Carolina, those of Vancouver's Island, and a large part of those of China. To the same age have been referred some at least of the coal beds of Australia and India. So important are these beds in China, that had geology originated in that country, the Mesozoic might have been our age of coal.

If the forests of the Mesozoic present a great advance over those of the Palæozoic, so do the animals of the land, which now embrace all the great types of vertebrate life. Some of these creatures have left strange evidence of their existence in their footprints on the sand and clay, now cemented into beds of hard rock excavated by the quarryman. If we had landed on some wide muddy Mesozoic shore, we might have found it marked in all directions with animal footprints. Some of these are shaped much like a human hand. The creature that made this mark was a gigantic successor of the crocodilian newts or labyrinthodonts of the Carboniferous, and this type seems to have attained its maximum in this period, where one species, *Labyrinthodon giganteus*, had great teeth three or four inches in length, and presenting in their cross section the most complicated foldings of enamel imaginable. But we may see on the shores still more remarkable footprints. They indicate biped and three-toed animals of gigantic

size, with a stride perhaps six feet in length. Were they enormous birds? If so, the birds of this age must have been giants which would dwarf even our ostriches. But as we walk along the shore we see many other impressions, some of them much smaller and different in form. Some, again, very similar in other respects, have four toes; and, more wonderful still, in tracing up some of the tracks, we find that here and there the creature has put down on the ground a sort of four-fingered hand, while some of these animals seem to have trailed long tails behind them. What were these portentous creatures—bird, beast, or reptile? The answer has been given to us by their bones, as studied by Von Meyer and Owen, and more recently by Huxley and Cope. We thus have brought before us the *Dinosaurs*—the terrible Saurians—of the Mesozoic age, the noblest of the Tanninim of old. These creatures constitute numerous genera and species, some of gigantic size, others comparatively small;—some harmless browsers on plants, others terrible renders of living flesh; but all remarkable for presenting a higher type of reptile organization than any now existing, and approaching in some respects to the birds and in others to the mammalia. Let us take one example of each of the principal groups. And first marches before us the *Iguanodon* or his relation *Hadrosaurus*—a gigantic biped, twenty feet or more in height, with enormous legs shaped like those of an ostrich, but of elephantine thickness. It strides along, not by leaps like a

kangaroo, but with slow and stately tread, occasionally resting, and supporting itself on the tripod formed by its hind limbs and a huge tail, like the inverted trunk of a tree. The upper part of its body becomes small and slender, and its head, of diminutive size and mild aspect, is furnished with teeth for munching the leaves and fruits of trees, which it can easily reach with its small fore-limbs, or hands, as it walks through the woods. The outward appearance of these creatures we do not certainly know. It is not likely that they had bony plates like crocodiles, but they may have shone resplendent in horny scale armour of varied hues. But another and more dreadful form rises before us. It is *Megalosaurus* or perhaps *Laelaps*. Here we have a creature of equally gigantic size and biped habits; but it is much more agile, and runs with great swiftness or advances by huge leaps, and its feet and hands are armed with strong curved claws; while its mouth has a formidable armature of sharp-edged and pointed teeth. It is a type of a group of biped bird-like lizards, the most terrible and formidable of rapacious animals that the earth has ever seen. Some of these creatures, in their short deep jaws and heads, resembled the great carnivorous mammals of modern times, while all in the structure of their limbs had a strange and grotesque resemblance to the birds. Nearly all naturalists regard them as reptiles; but in their circulation and respiration they must have approached to the mammalia, and their general habit of body recalls that of

the kangaroos. They were no doubt oviparous; and this, with their biped habit, seems to explain the strong resemblance of their hind quarters to those of birds. Had we seen the eagle-clawed Lælaps rushing on his prey; throwing his huge bulk perhaps thirty feet through the air, and crushing to the earth under his gigantic talons some feebler Hadrosaur, we should have shudderingly preferred the companionship of modern wolves and tigers to that of those savage and gigantic monsters of the Mesozoic.

We must not leave the great land-lizards of the reptilian age, without some notice of that Goliath of the race which, by a singular misnomer, has received the appellation of *Ceteosaurus* or "Whale-Saurian." It was first introduced to naturalists by the discovery of a few enormous vertebræ in the English Oolite; and as these in size and form seemed best to fit an aquatic creature, it was named in accordance with this view. But subsequent discoveries have shown that, incredible though this at first appeared; the animal had limbs fitted for walking on the land. Professor Phillips has been most successful in collecting and restoring the remains of *Ceteosaurus*, and devotes to its history a long and interesting section of his "Geology of Oxford." The size of the animal may be estimated, from the fact that its thigh-bone is sixty-four inches long, and thick in proportion. From this and other fragments of the skeleton, we learn that this huge monster must have stood ten feet high when on all fours, and that its

length could not have been less than fifty feet; perhaps much more. From a single tooth, which has been found, it seems to have been herbivorous; and it was probably a sort of reptilian Hippopotamus, living on the rich herbage by the sides of streams and marshes, and perhaps sometimes taking to the water, where the strokes of its powerful tail would enable it to move more rapidly than on the land. In structure, it seems to have been a composite creature, resembling in many points the contemporary Dinosaurs; but in others, approaching to the crocodiles and the lizards.

But the wonders of Mesozoic reptiles are not yet exhausted. While noticing numerous crocodiles and lizard-like creatures, and several kinds of tortoises, we are startled by what seems a flight of great bats, wheeling and screaming overhead, pouncing on smaller creatures of their own kind, as hawks seize sparrows and partridges, and perhaps diving into the sea for fish. These were the Pterodactyles, the reptile bats of the Mesozoic. They fly by means of a membrane stretched on a monstrously enlarged little finger, while the other fingers of the fore limb are left free to be used as hands or feet. To move these wings, they had large breast-muscles like those of birds. In their general structure, they were lizards, but no doubt of far higher organization than any animals of this order now living; and in accordance with this, the interior of their skull shows that they must have had a brain comparable with

that of birds, which they rivalled in energy and intelligence. Some of them were larger than the largest modern birds of prey, others were like pigeons and snipes in size. Specimens in the Cambridge Museum indicate one species twenty feet in the expanse of its wings. Cope has recently described an equally gigantic species from the Mesozoic of Western America, and fragments of much larger species are said to exist.* Imagine such a creature, a flying dragon, with vast skinny wings, its body, perhaps, covered with scales, both wings and feet armed with strong claws, and with long jaws furnished with sharp teeth. Nothing can be conceived more strange and frightful. Some of them had the hind limbs long, like wading birds. Some had short legs, adapted perhaps for perching. They could probably fold up their wings, and walk on all fours. Their skeleton, like that of birds, was very light, yet strong; and the hollow bones have pores, which show that, as in birds, air could be introduced into them from the lungs. This proves a circulation resembling that of birds, and warm blood. Indeed, in many respects, these creatures bridge over the space between the birds and the reptiles. "That they lived," says Seeley, "exclusively upon land or in the air is improbable, considering the circumstances under which their remains are found. It is likely that they haunted the sea-shores; and while sometimes rowing themselves over the water with their powerful wings,

* Seeley: "*Ornithosauria*."

used the wing membrane, as does the bat, to enclose the prey and bring it to the mouth. The large Pterodactyles probably pursued a more substantial prey than dragon-flies. Their teeth were well suited for fish; but probably fowl and small mammal, and even fruits, made a variety in their food. As the lord of the cliff, it may be supposed to have taken toll of all animals that could be conquered with tooth and nail: From its brain, it might be regarded as an intelligent animal. The jaws present indications of having been sheathed with a horny covering, and some species show a rugose anterior termination of the snout, suggestive of fleshy lips like those of the bat, and which may have been similarly used to stretch and clean the wing-membrane."

Here, however, perched on the trees, we see true birds. At least they have beaks, and are clothed with feathers. But they have very strange wings, the feathers all secondaries, without any large quills, and several fingers with claws at the angle of the wing, so that though less useful as wings, they served the double purpose of wing and hand. More strange still, the tail was long and flexible, like that of a lizard, with the feathers arranged in rows along its sides. If the lizards of this strange and uncertain time had wings like bats, the birds had tails and hands like lizards. This was in short the special age of reptiles, when animals of that class usurped the powers which rightfully belonged to creatures yet in their nonage, the true birds and mammals of

our modern days, while the birds were compelled to assume some reptilian traits.

Yet, strange to say, representatives of the higher creatures destined to inherit the earth at a later date actually existed. Toward the close of the Mesozoic we find birds approaching to those of our own day, and almost at the beginning of the time there were small mammals, remains of which are found both in the earlier and later formations of the Mesozoic, but which never seem to have thriven; at least so far as the introduction of large and important species is concerned. Traversing the Mesozoic woods, we might see here and there little hairy creatures, which would strike a naturalist as allies of the modern bandicoots, kangaroo rats, and myrmecobius of Australia; and closer study would confirm this impression, though showing differences of detail. In their teeth, their size, and general form, and probably in their pouched or marsupial reproduction, these animals were early representatives of the smaller quadrupeds of the Austral continent, creatures which are not only small but of low organisation in their class.

One of these mammals, known to us only by its teeth, and well named *Microlestes*, the "little thief," sneaks into existence, so to speak, in the Trias of Europe, while another very similar, *Dromatherium*, appears in rocks of similar age in America; and this is the small beginning of the great class Mammalia, destined in its quadrupedal forms to culminate in the elephants and their contemporaries in the Tertiary

period. Who that saw them trodden under foot by the reptile aristocracy of the Mesozoic could have divined their destiny? But, notwithstanding the struggle for existence, the weakest does not always "go to the wall." The weak things of this world are often chosen to confound those that are mighty; and the little quadrupeds of the Mesozoic are an allegory. They may typify the true, the good, and the hopeful, mildly and humbly asserting themselves in the world that now is, in the presence of the dragon monsters of pride and violence, which in the days to come they will overthrow. Physically the Mesozoic has passed away, but still exists morally in an age of evil reptiles, whose end is as certain as that of the great Dinosaurs of the old world.

The Mesozoic mammals are among the most interesting fossils known to us. In a recent memoir by Professor Owen, thirty-three species are indicated—all, or nearly all, Marsupial—all small—all closely allied to modern Australian animals; some herbivorous, some probably carnivorous. Owen informs us that these animals are not merely marsupials, but marsupials of low grade, a point in which, however, Huxley differs somewhat in opinion. They are at least not lower than some that still exist, and not so low as those lowest of mammals in Modern Australia, the duck-billed platypus and the echidna. Owen further supposes that they were possibly the first mammals, and not only the predecessors but the progenitors of the modern marsupials. If so, we have

the singular fact that they not only did not improve throughout the vast Mesozoic time, but that they have been in the progress of subsequent geological ages expelled out of the great eastern continent, and, with the exception of the American opossums, banished, like convicts, to Australia. Yet, notwithstanding their multiplied travels and long experiences, they have made little advance. It thus seems that the Mesozoic mammals were, from the evolutionist point of view, a decided failure, and the work of introducing mammals had to be done over again in the Tertiary; and then, as we shall find, in a very different way. If nothing more, however, the Mesozoic mammals were a mute prophecy of a better time, a protest that the age of reptiles was an imperfect age, and that better things were in store for the world. Moses seems to have been more hopeful of them than Owen or even Huxley would have been. He says that God "created" the great Tanninim, the Dinosaurs and their allies, but only "made" the mammals of the following creative day; so that when *Microlestes* and his companions quietly and unnoticed presented themselves in the Mesozoic, they would appear in some way to have obviated, in the case of the tertiary mammals, the necessity of a repetition of the greater intervention implied in the word "create." How that was effected none of us know; but, perhaps, we may know hereafter.

CHAPTER IX.

THE MESOZOIC AGES—(*continued*).

THE waters of the Mesozoic period present features quite as remarkable as the land. In our survey of their teeming multitudes, we indeed scarcely know where to begin or whither to turn. Let us look first at the higher or more noble inhabitants of the waters. And here, just as in the case of the greater animals of the land, the Mesozoic was emphatically an age of reptiles. In the modern world the highest animals the sea are mammals, and these belong to three great and somewhat diverse groups. The first is that of the seals and their allies, the walruses, sea-lions, etc. The second is that of the whales and dolphins and porpoises. The third is that of the manatees, or dugongs. All these creatures breathe air, and bring forth their young alive, and nourish them with milk. Yet they all live habitually or constantly in the water. Between these aquatic mammals and the fishes, we have some aquatic reptiles—as the turtles, and a few sea-snakes and sea-lizards, and crocodiles; but the number of these is comparatively small, and in the more temperate latitudes there are scarcely any of them.

All this was different in the Mesozoic. In so far as we know, there were no representatives of the seals

and whales and their allies, but there were vast numbers of marine reptiles, and many of these of gigantic size. Britain at present does not possess one large reptile, and no marine reptile whatever. In the Mesozoic, in addition to the great Dinosaurs and Pterodactyls of the land, it had at least fifty or sixty species of aquatic reptiles, besides many turtles. Some of these were comparable in size with our modern whales, and armed with tremendous powers of destruction. America is not relatively rich in remains of Mesozoic Saurians, yet while the existing fauna of the temperate parts of North America is nearly destitute of aquatic reptiles, with the exception of the turtles, it can boast, according to Cope's lists, about fifty Mesozoic species, many of them of gigantic size, and the number of known species is increasing every year. When it is taken in connection with these statistics, that while we know all the modern species, we know but a small percentage of the fossils, the discrepancy becomes still more startling. Further, from the number of specimens and fragments found, it is obvious that these great aquatic saurians were by no means rare; and that some of the species at least must have been very abundant. Could we have taken our post on the Mesozoic shore, or sailed over its waters, we should have found ourselves in the midst of swarms of these strange, often hideous, and always grotesque creatures.

Let us consider for a little some of the more conspicuous forms, referring to our illustration for their

portraits. Every text-book figures the well-known types of the genera *Ichthyosaurus* and *Plesiosaurus*; we need scarcely, therefore, dwell on them, except to state that the catalogues of British fossils include eleven species of the former genus and eighteen of the latter. We may, however, notice some of the less familiar points of comparison of the two genera. Both were aquatic, and probably marine. Both swam by means of paddles; both were carnivorous, and probably fed principally upon fishes; both were proper reptiles, and breathed air, and had large and capacious lungs. Yet with these points in common, no two animals could have been more different in detail. The *Ichthyosaurus* had an enormous head, with powerful jaws, furnished with numerous and strong teeth. Its great eyes, strengthened by a circle of bony plates, exceeded in dimensions, and probably in power of vision under water, those of any other animal, recent or fossil. Its neck was short, its trunk massive, with paddles or swimming limbs of comparatively small size, and a long tail, probably furnished with a caudal fin or paddle for propulsion through the water. The *Plesiosaur*, on the other hand, had a small and delicate head, with slender teeth and small eyes. Its neck, of great length and with numerous joints, resembled the body of a serpent. Its trunk, short, compact, and inflexible, was furnished with large and strong paddles, and its tail was too short to be of any service except for steering. Compared with the *Ichthyosaurus*, it was what the giraffe is to the

rhinoceros, or the swan to the porpoise. Two fishermen so variously and differently fitted for their work it would be difficult to imagine. But these differences were obviously related to corresponding differences in food and habit. The Ichthyosaur was fitted to struggle with the waves of the stormy sea, to roll therein like modern whales and grampuses, to seize and devour great fishes, and to dive for them into the depths; and its great armour-plated eyes must have been well adapted for vision in the deeper waters. The Plesiosaur, on the contrary, was fitted for comparatively still and shallow waters; swimming near the surface with its graceful neck curving aloft, it could dart at the smaller fishes on the surface, or stretch its long neck downward in search of those near the bottom. The Ichthyosaurs rolled like porpoises in the surf of the Liassic coral reefs and the waves beyond; the Plesiosaurs careered gracefully in the quiet waters within. Both had their beginning at the same time in the earlier Mesozoic, and both found a common and final grave in its later sediments. Some of the species were of very moderate size, but there were Ichthyosaurs twenty five feet long, and Plesiosaurs at least eighteen feet in length.

Another strange and monstrous group of creatures, the Elasmosaurs and their allies, combined the long neck of Plesiosaurs with the swimming tail of Ichthyosaurs, the latter enormously elongated, so that these creatures were sometimes fifty feet in length, and whale-like in the dimensions of their bodies. It is

curious that these composite creatures belong to a later period of the Mesozoic than the typical Ichthyosaurs and Plesiosaurs, as if the characters at one time separated in these genera had united in their successors.

One of the relatives of the Plesiosaurs, the Pliosaur, of which genus several species of great size are known, perhaps realized in the highest degree possible the idea of a huge marine predaceous reptile. The head in some of the species was eight feet in length, armed with conical teeth a foot long. The neck was not only long, but massive and powerful, the paddles, four in number, were six or seven feet in length and must have urged the vast bulk of the animal, perhaps forty feet in extent, through the water with prodigious speed. The capacious chest and great ribs show a powerful heart and lungs. Imagine such a creature raising its huge head twelve feet or more out of water, and rushing after its prey, impelled with perhaps the most powerful oars ever possessed by any animal. We may be thankful that such monsters, more terrible than even the fabled sea-serpent, are unknown in our days. Buckland, I think, at one time indulged in the *jeu d'esprit* of supposing an Ichthyosaur lecturing on the human skull. "You will at once perceive," said the lecturer, "that the skull before us belonged to one of the lower orders of animals. The teeth are very insignificant, the power of the jaws trifling, and altogether it seems wonderful how the creature could have procured food." We cannot retort on the

Ichthyosaur and his contemporaries, for we can see that they were admirably fitted for the work they had in hand ; but we can see that had man been so unfortunate as to have lived in their days, he might have been anything but the lord of creation.

But there were sea-serpents as well as other monsters in the Mesozoic seas. Many years ago the Lower Cretaceous beds of St. Peter's Mount, near Maestricht, afforded a skull three feet in length, of massive proportions, and furnished with strong conical teeth, to which the name *Mosasaurus Camperi* was given. The skull and other parts of the skeleton found with it, were held to indicate a large aquatic reptile, but its precise position in its class was long a subject of dispute. Faujas held it to be a crocodile ; Camper, Cuvier, and Owen regarded it as a gigantic lizard. More recently, additional specimens, especially those found in the Cretaceous formations of North America, have thrown new light upon its structure, and have shown it to present a singular combination of the character of serpents, lizards, and of the great sea saurians already referred to. Some parts of the head and the articulation of the jaws, in important points resemble those of serpents, while in other respects the head is that of a gigantic lizard. The body and tail are greatly lengthened out, having more than a hundred vertebral joints, and in one of the larger species attaining the length of eighty feet. The trunk itself is much elongated, and with ribs like those of a snake. There are no walking feet, but a pair of fins or paddles

like those of *Ichthyosaurus*. Cope, who has described these great creatures as they occur in the Cretaceous of the United States, thus sketches the *Mosasaur*: "It was a long and slender reptile, with a pair of powerful paddles in front, a moderately long neck, and flat pointed head. The very long tail was flat and deep, like that of a great eel, forming a powerful propeller. The arches of the vertebral column were more extensively interlocked than in any other reptiles except the snakes. In the related genus *Clidastes* this structure is as fully developed as in the serpents, so that we can picture to ourselves its well-known consequences; their rapid progress through the water by lateral undulations, their lithe motions on the land, the rapid stroke, the ready coil, or the elevation of the head and vertebral column, literally a living pillar, towering above the waves or the thickets of the shore swamps." As in serpents, the mouth was wide in its gape, and the lower jaw capable of a certain separation from the skull to admit of swallowing large prey. Besides this the lower jaw had an additional peculiarity, seen in some snakes, namely, a joint in the middle of the jaw enabling its sides to expand, so that the food might be swallowed "between the branches of the jaw." Perhaps no creatures more fully realize in their enormous length and terrible powers the great Tanninim (the stretched-out or extended reptiles) of the fifth day of the Mosaic record, than the *Mosasaurus* and *Elasmosaurus*. When Mr. Cope showed me, a few years ago, a nearly complete skeleton

of *Elasmosaurus*, which for want of space he had stretched on a gallery along two sides of a large room, I could not help suggesting to him that the name of the creature should be *Teinosaurus** instead of that which he had given. Marsh has recently ascertained that the Mosasaurs were covered in part at least with bony scales.

These animals may serve as specimens of the reptilian giants of the Mesozoic seas; but before leaving them we must at least invite attention to the remarkable fact that they were contemporary with species which represent the more common aquatic reptiles of the modern world. In other words, the monsters which we have described existed over and above a far more abundant population of crocodiles and turtles than the modern waters can boast. The crocodiles were represented both in Europe and America by numerous and large species, most of them with long snouts like the modern Gavials, a few with broad heads like those of the alligators. The turtles again presented not only many species, but most of the aquatic subdivisions of the group known in modern times, as for instance the Emydes or ordinary fresh-water forms, the snapping turtles, and the soft-shelled turtles. Cope says that the Cretaceous of New Jersey alone affords twenty species, one of them a snapping turtle six feet in length. Owen records

*Heb. *Tanan*; Gr. *Teino*, *Tanuo*; Sansc. *Tanu*; Lat. *Tendo*.
—Ges. Lex.



LIFE IN THE MESOZOIC PERIOD.
Aquatic Reptiles and Cephalopods. Reptiles.—Plesiosaur and Osteopygis, Ichthyosaur, Teliosaur, Plesiosaur, Elasmosaur, Mosasaur (in order of the heads from left to right).—Cephalopods.—Ammonite, Criocerat, Belemnites, Baculites, and Ammonites (in order from left to right). The Reptiles after Hawkins and Cope's Restorations.

above a dozen large species from the Upper Mesozoic of England, and dates the first appearance of the turtles in England about the time of the Portland stone, or in the upper half of the Mesozoic; but footprints supposed to be those of turtles are found as far back as the Trias. Perhaps no type of modern reptiles is more curiously specialized than these animals, yet we thus find them contemporaneous with many generalized types, and entering into existence perhaps as soon as they. The turtles did not culminate in the Mesozoic, but go on to be represented by more numerous and larger species in the Tertiary and Modern. In the case of the crocodiles, while they attained perhaps a maximum toward the end of the Mesozoic, it was in a peculiar form. The crocodiles of this old time had vertebræ with a hollow at each end like the fishes, or with a projection in the front. At the end of the Mesozoic this was changed, and they assumed a better-knit back, with joints having a ball behind and a socket in front. In the Cretaceous age, species having these two kinds of backbone were contemporaneous. Perhaps this improvement in the crocodilian back had something to do with the persistence of this type after so many others of the sea-lizards of the Mesozoic had passed away.

Of the fishes of the Mesozoic we need only say that they were very abundant, and consisted of sharks and ganoids of various types, until near

the close of the period, when the ordinary horny-scaled fishes, such as abound in our present seas, appear to have been introduced. One curious point of difference is that the unequally lobed tail of the Palæozoic fishes is dropped in the case of the greater part of the ganoids, and replaced by the squarely-cut tail prevalent in modern times.

In the sub-kingdom of the Mollusca many important revolutions occurred. Among the lampshells a little *Leptaena*, no bigger than a pea, is the last and depauperated representative of a great Palæozoic family. Another, that of the Spirifers, still shows a few species in the Lower Mesozoic. Others, like *Rhynchonella*, and *Terebratula*, continue through the period, and extend into the Modern. Passing over the ordinary bivalves and sea-snails, which in the main conform to those of our own time, we find perhaps the most wonderful changes among the relatives of the cuttle-fishes and Nautili. As far back as the Silurian we find the giant *Orthoceratites* contemporary with Nautili, very like those of the present ocean. With the close of the Palæozoic, however, the *Orthoceratites* and their allies disappear, while the Nautili continue, and are reinforced by multitudes of new forms of spiral chambered shells, some of them more wonderful and beautiful than any of those which either preceded or followed them. Supreme among these is the great group of the *Ammonites*, — beautifully spiral shells, thin and pearly like the *Nautilus*, and

chambered like it, so as to serve as a float, but far more elaborately constructed, inasmuch as the chambers were not simply curved, but crimped and convoluted, so as to give the outer wall much more effectual support. This outer wall, too, was worked into ornamental ribs and bands, which not only gave it exquisite beauty, but contributed to combine strength to resist pressure with the lightness necessary to a float. In some of these points it is true the *Gyroceras* and *Goniatites* of the Palæozoic partially anticipated them, but much less perfectly. The animals which inhabited these shells must have been similar to that of *Nautilus*, but somewhat different in the proportion of parts. They must have had the same power of rising and sinking in the water, but the mechanical construction of their shells was so much more perfect relatively to this end, that they were probably more active and locomotive than the *Nautili*. They must have swarmed in the Mesozoic seas, some beds of limestone and shale being filled with them; and as many as eight hundred species of this family are believed to be known, including, however, such forms as the *Baculites* or straight *Ammonites*, bearing to them perhaps a relation similar to that of *Orthoceras* to *Nautilus*. Further, some of the *Ammonites* are of gigantic size, one species being three feet in diameter, while others are very minute. The whole family of *Ammonitids*, which begins to be in force in the *Trias*, disappears at the end of

the Mesozoic, so that this may be called the special age of Ammonites as well as of reptiles.

Further, this time was likewise distinguished by the introduction of true cuttle-fishes, the most remarkable of which were those furnished with the internal supports or "bones," known as *Belemnites*, from a fancied resemblance to javelins or thunderbolts, a comparison at least as baseless as that often made in England of the Ammonites to fossil snakes. The shell of the Belemnite is a most curious structure. Its usual general shape is a pointed cylinder or elongated cone. At top it has a deep cavity for the reception of certain of the viscera of the animal. Below this is a conical series of chambers, the Phragmacone; and the lower half of the shell is composed of a solid shelly mass or guard, which, in its structure of radiating fibres and concentric layers, resembles a stalactite, or a petrified piece of exogenous wood. This structure was an internal shell or support like those of the modern cuttle-fishes; but it is difficult to account for its peculiarities, so much more complex than in any existing species. The most rational supposition seems to be that it was intended to serve the triple purpose of a support, a float, and a sinker. Unlike the shell of a Nautilus, if thrown into the water it would no doubt have sunk, and with the pointed end first. Consequently, it was not a float simply, but a float and sinker combined, and its effect must have been to keep the animal at the

bottom, with its head upward. The Belemnite was therefore an exceptional cuttle-fish, intended to stand erect on the sea-bottom and probably to dart upward in search of its prey; for the suckers and hooks with which its arms were furnished show that, like other cuttle-fishes, it was carnivorous and predaceous. The guard may have been less ponderous when recent than in the fossil specimens, and in some species it was of small size or slender, and in others it was hollow. Possibly, also, the soft tissues of the animal were not dense, and it may have had swimming fins at the sides. In any case they must have been active creatures, and no doubt could dart backward by expelling water from their gill chamber, while we know that they had ink-bags, provided with that wonderfully divided pigment, inimitable by art, with which the modern *Sepia* darkens the water to shelter itself from its enemies. The Belemnites must have swarmed in the Mesozoic seas; and as squids and cuttles now afford choice morsels to the larger fishes, so did the Belemnites in their day. There is evidence that even the great sea-lizards did not disdain to feed on them. We can imagine a great shoal of these creatures darting up and down, seizing with their ten hooked arms their finny or crustacean prey. In an instant a great fish or saurian darts down among them; they blacken the water with a thick cloud of inky secretion and disperse on all sides, while their enemy, blindly

seizing a few mouthfuls, returns sullenly to the surface. A great number of species of Belemnites and allied animals have been described; but it is probable that in naming them too little regard has been paid to distinctions of age and sex. The Belemnites were for the most part small creatures; but there is evidence that there existed with them some larger and more formidable cuttles; and it is worthy of note that, in several of these, the arms, as in the Belemnites, were furnished with hooks as well as suckers, an exceptional arrangement in their modern allies. It is probable that while the four-gilled or shell-bearing cuttles culminated in size and perfection in the Ammonitids of the Mesozoic, the modern cuttles of the two-gilled and shell-less type are grander in dimensions than their Mesozoic predecessors. It is, however, not a little singular that a group so peculiar and apparently so well provided with means, both of offence and defence, as the Belemnites, should come in and go out with the Mesozoic, and that the Nautiloid group, after attaining to the magnitude and complexity of the great Ammonites, should retreat to a few species of diminutive and simply-constructed Nautili; and in doing so should return to one of the old types dating as far back as the older Palæozoic, and continuing unchanged through all the intervening time.

The Crustaceans of the Mesozoic had lost all the antique peculiarities of the older time, and had so

much of the aspect of those of the present day, that an ordinary observer, if he could be shown a quantity of Jurassic or Cretaceous crabs, lobsters, and shrimps, would not readily recognise the difference, which did not exceed what occurs in distant geographical regions in the present day. The same remark may be made as to the corals of the Mesozoic; and with some limitations, as to the star-fishes and sea-urchins, which latter are especially numerous and varied in the Cretaceous age. In short, all the invertebrate forms of life, and the fishes and reptiles among the vertebrates, had already attained their maximum elevation in the Mesozoic; and some of them have subsequently sunk considerably in absolute as well as relative importance.

In the course of the Mesozoic, as indicated in the last chapter, there had been several great depressions and re-elevations of the Continental Areas. But these had been of the same quiet and partial character with those of the Palæozoic, and it was not until the close of the Mesozoic time, in the Cretaceous age, that a great and exceptional subsidence involved for a long period the areas of our present continents in a submergence wider and deeper than any that had previously occurred since the dry land first rose out of the waters.

Every one knows the great chalk beds which appear in the south of England, and which have given its name to the latest age of the Mesozoic. This great

deposit of light-coloured and usually soft calcareous matter attains in some places to the enormous thickness of 1,000 feet. Nor is it limited in extent. According to Lyell, its European distribution is from Ireland to the Crimea, a distance of 1,140 geographical miles; and from the south of France to Sweden, a distance of 840 geographical miles. Similar rocks, though not in all cases of the precise nature of chalk, occur extensively in Asia and in Africa, and also in North and South America.

But what is chalk? It was, though one of the most familiar, one of the most inscrutable of rocks, until the microscope revealed its structure. The softer varieties, gently grated or kneaded down in water, or the harder varieties cut in thin slices, show a congeries of microscopic chambered shells belonging to the humble and simple group of Protozoa. These shells and their fragments constitute the material of the ordinary chalk. With these are numerous spicules of sponges and silicious cell-walls of the minute one-celled plants called Diatoms. Further, the flinty matter of these organisms has by the law of molecular attraction been collected into concretions, which are the flints of the chalk. Such a rock is necessarily oceanic; but more than this, it is abyssal. Laborious dredging has shown that similar matter is now being formed only in the deep bed of the ocean, whither no sand or mud is drifted from the land, and where the countless hosts of microscopic shell-bearing protozoa continually drop their little skeletons on the bottom,

slowly accumulating a chalky mud or slime. That such a rock should occur over vast areas of the continental plateaus, that both in Europe and America it should be found to cover the tops of hills several thousand feet high, and that its thickness should amount to several hundreds of feet, are facts which evidence a revolution more stupendous perhaps than that at the close of the Palæozoic. For the first time since the Laurentian, the great continental plateaus changed places with the abysses of the ocean, and the successors of the Laurentian Eozoon again reigned on surfaces which through the whole lapse of Palæozoic and Mesozoic time had been separated more or less from that deep ocean out of which they rose at first. This great Cretaceous subsidence was different from the disturbances of the Permian age. There was at first no crumpling of the crust, but merely a slow and long-continued sinking of the land areas, followed, however, by crumpling of the most stupendous character, which led at the close of the Cretaceous and in the earlier Tertiary to the formation of what are now the greatest mountain chains in the world. As examples may be mentioned the Himalaya, the Andes, and the Alps, on all which the deep-sea beds of the Cretaceous are seen at great elevations. In Europe this depression was almost universal, only very limited areas remaining out of water. In America a large tract remained above water in the region of the Appalachians. This gives us some clue to the phenomena. The great Permian collapse led to the

crumpling-up of the Appalachians and the Urals, and the older hills of Western Europe. The Cretaceous collapse led to the crumpling of the great N.W. and S.E. chain of the Rocky Mountains and Andes, and to that of the east and west chains of the south of Asia and Europe. The cause was probably in both cases the same; but the crust gave way in a different part, and owing to this there was a greater amount of submergence of our familiar continental plateaus in the Cretaceous than in the Permian.

Another remarkable indication of the nature of the Cretaceous subsidence, is the occurrence of beds filled with grains of the mineral Glauconite or "green-sand." These grains are not properly sand, but little concretions, which form in the bottom of the deep sea, often filling and taking casts of the interior and fine tubes of Foraminiferal shells. Now this Glauconite, a hydrous silicate of iron and potash, is akin to similar materials found filling the pores of fossils in Silurian beds. It is also akin to the Serpentine filling the pores of Eozoon in the Laurentian. Such materials are formed only in the deeper parts of the ocean, and apparently most abundantly where currents of warm water are flowing at the surface, as in the area of the Gulf Stream. Thus, not only in the prevalence of Foraminifera, but in the formation of hydrous silicates, does the Cretaceous recall the Laurentian. Such materials had no doubt been forming, and such animals living in the ocean depths, all through the intervening ages, but with the exception of a few and merely

local instances, we know nothing of them, till the great subsidence and re-elevation of the Cretaceous again allows them to ascend to the continental plateaus, and again introduces us to this branch of the world-making process.

The attention recently drawn to these facts by the researches of Dr. Carpenter and others, and especially the similarity in mineral character and organic remains of some of the deposits now forming in the Atlantic and those of the chalk, have caused it to be affirmed that in the bed of the Atlantic these conditions of life and deposit have continued from the Cretaceous up to the present time, or as it has been expressed, that "we are still living in the Cretaceous epoch." Now, this is true or false just as we apply the statement. We have seen that the distinction between abyssal areas, continental oceanic plateaus, and land surfaces has extended through the whole lapse of geological time. In this broad sense we may be said to be still living in the Laurentian epoch. In other words, the whole plan of the earth's development is one and the same, and each class of general condition once introduced is permanent somewhere. But in another important sense we are not living in the Cretaceous epoch; otherwise the present site of London would be a thousand fathoms deep in the ocean; the Ichthyosaurs and Ammonites would be sporting themselves in the water, and the huge Dinosaurs and strange Pterodactyls living on the land. The Italian peasant is still in many important points living

in the period of the old Roman Empire. The Arab of the desert remains in the Patriarchal period, and there are some tribes not yet beyond the primitive age of stone. But the world moves, nevertheless, and the era of Victoria is not that of the Plantagenets or of Julius Cæsar. So while we may admit that certain of the conditions of the Cretaceous seas still prevail in the bed of the present ocean, we must maintain that nearly all else is changed, and that the very existence of the partial similarity is of itself the most conclusive proof of the general want of resemblance, and of the thorough character of the changes which have occurred.

The duration of the Cretaceous subsidence must have been very great. We do not know the rate at which the Foraminifera accumulate calcareous mud. In some places, where currents heap up their shells, they may be gathered rapidly; but on the average of the ocean bed, a foot of such material must indicate the lapse of ages very long when compared with those of modern history. We need not wonder, therefore, that while some forms of deep-sea Cretaceous life, especially of the lower grades, seem to have continued to our time, the inhabitants of the shallow waters and the land have perished; and that the Neozoic or Tertiary period introduces us to a new world of living beings. I say we need not wonder; yet there is no reason why we should expect this as a necessary consequence. As the Cretaceous deluge rose over the continents of the Mesozoic, the great sea saurians might have fol-

lowed. Those of the land might have retreated to the tracts still remaining out of water, and when the dry land again appeared in the earlier Tertiary, they might again have replenished the earth, and we might thus have truly been living in the Reptilian age up to this day. But it was not so. The old world again perished, and the dawn of the Tertiary shows to us at once the dynasties of the Mammalian age, which was to culminate in the introduction of man. With the great Cretaceous subsidence the curtain falls upon the age of reptiles, and when it rises again, after the vast interval occupied in the deposition of the greensand and chalk, the scene has entirely changed. There are new mountains and new plains, forests of different type, and animals such as no previous age had seen.

How strange and inexplicable is this perishing of types in the geological ages! Some we could well spare. We would not wish to have our coasts infested by terrible sea saurians, or our forests by carnivorous Dinosaurs. Yet why should these tyrants of creation so utterly disappear without waiting for us to make war on them? Other types we mourn. How glorious would the hundreds of species of Ammonites have shone in the cases of our museums, had they still lived! What images of beauty would they have afforded to the poets who have made so much of the comparatively humble Nautilus! How perfectly, too, were they furnished with all those mechanical appliances for their ocean life, which are bestowed

only with a niggardly hand on their successors!
Nature gives us no explanation of the mystery.

“From scarpèd cliff and quarried stone,
She cries—‘A thousand types are gone.’”

But why or how one was taken and another left she is silent, and I believe must continue to be so, because the causes, whether efficient or final, are beyond her sphere. If we wish for a full explanation, we must leave Nature, and ascend to the higher domain of the Spiritual.

CONDENSED TABULAR VIEW OF THE AGES AND PERIODS OF THE MESOZOIC.

Time.	Ages.	Periods.	Animals and Plants.
	CRETACEOUS.	Newer. { Maestricht beds; Fox Hill and Pierre Groups of Western Ameri- ca; Greensand of N. Jersey. Middle. { Chalk; Benton and Dakota Groups of Western America. Older. { Lower Greensand and Gault; Lower Clays of New Jersey and Alabama.	Beginning of Age of Angiosperms Ekogens. "And God created great reptiles, and every living moving thing which the waters brought forth abundantly, and every flying creature after its kind." Ages of Cycads and Pines.
	UPPER JURASSIC	N. Purbeck Beds. M. Portland Limestone. O. Portland Sandstone.	Culmination of Reptilian Ages.
	MIDDLE JURASSIC	N. Kimmeridge Clay, etc. M. Coralline Limestone O. Calcareous Grit & Oxford Clay.	Duration of Ammonites and Belemnites.
	LOWER JURASSIC	N. Cornbrash & Forest Mar- ble. M. Great & Inferior Oolites, etc. O. Lias Clay and Lime- stone.	Appearance of Mammals and Birds.
	TRIASSIC.	Upper Triassic { Sandstones of Prince Edward I., M. Muschelkalk. { Connecticut, etc. Lower Triassic { Sandstones of Prince Edward I., O. Bunter Sandstone { Connecticut, etc.	Beginning of Reptilian Ages.

MESOZOIC.

CHAPTER X.

THE NEOZOIC AGES.

BETWEEN the Mesozoic and the next succeeding time, which may be known as the Neozoic or Tertiary,* there is in the arrangements of most geologists a great break in the succession of life; and undoubtedly the widespread and deep subsidence of the Cretaceous, followed by the elevation of land on a great scale at the beginning of the next period, is a physical cause sufficient to account for vast life changes. Yet we must not forget to consider that even in the Cretaceous itself there were new features beginning to appear. Let us note in this way, in the first place, the introduction of the familiar generic forms of exogenous trees. Next we may mention the decided prevalence of the modern types of coral animals and of a great number of modern generic forms of mollusks. Then we have the establishment of the modern tribes of lobsters and crabs, and the appearance of nearly all the orders of insects. Among vertebrates, the ordinary fishes are now introduced. Modern orders of

* The former name is related to Palæozoic and Mesozoic, the latter to the older terms Primary and Secondary. For the sake of euphony we shall use both. The term Neozoic was proposed by Edward Forbes for the Mesozoic and Cainozoic combined; but I use it here as a more euphonic and accurate term for the Cainozoic alone.

reptiles, as the crocodiles and chelonians, had already appeared, and the first mammals. Henceforth the progress of organic nature lies chiefly in the dropping of many Mesozoic forms and in the introduction of the higher tribes of mammals and of man.

It is further to be observed that the new things introduced in the later Mesozoic came in little by little in the progress of the period, and anticipated the great physical changes occurring at its close. On the other hand, while many family and even generic types pass over from the Mesozoic to the earlier Tertiary, very few species do so. It would seem, therefore, as if changes of species were more strictly subordinate to physical revolutions than were changes of genera and orders—these last overriding under different specific forms many minor vicissitudes, and only in part being overwhelmed in the grander revolutions of the earth.

Both in Europe and America there is evidence of great changes of level at the beginning of the Tertiary. In the west of Europe beds often of shallow-water or even fresh-water origin fill the hollows in the bent Cretaceous strata. This is manifestly the case with the formations of the London and Paris basins, contemporaneous but detached deposits of the Tertiary age, lying in depressions of the chalk. Still this does not imply much want of conformity, and according to the best explorers of those Alpine regions in which both the Mesozoic and Tertiary beds have been thrown up to great elevations, they are in the main conformable to one another. Something of the

same kind occurs in America. On the Atlantic coast the marine beds of the Older Tertiary cover the Cretaceous, and little elevation seems to have occurred. Farther west the elevation increases, and in the upper part of the valley of the Mississippi it amounts to 1700 feet. Still farther west, in the region of the Rocky Mountains, there is evidence of elevation to the extent of as much as 7000 feet. Throughout all these regions scarcely any disturbance of the old Cretaceous sea-bottom seems to have occurred until after the deposition of the older Tertiary, so that there was first a slow and general elevation of the Cretaceous ocean bottom, succeeded by gigantic folds and fractures, and extensive extravasations of the bowels of the earth in molten rocks, in the course of the succeeding Tertiary age. These great physical changes inaugurated the new and higher life of the Tertiary, just as the similar changes in the Permian did that of the Mesozoic.

The beginning of these movements consisted of a great and gradual elevation of the northern parts of both the Old and New Continents out of the sea, whereby a much greater land surface was produced, and such changes of depth and direction of currents in the ocean as must have very much modified the conditions of marine life. The effect of all these changes in the aggregate was to cause a more varied and variable climate, and to convert vast areas previously tenanted by marine animals into the abodes of animals and plants of the land, and of estuaries, lakes, and shallow waters. Still, however, very large areas

now continental were under the sea. As the Tertiary period advanced, these latter areas were elevated, and in many cases were folded up into high mountains. This produced further changes of climate and habitat of animals, and finally brought our continents into all the variety of surface which they now present, and which fits them so well for the habitation of the higher animals and of man.

The thoughtful reader will observe that it follows from the above statements that the partial distribution and diversity in different localities which apply to the deposits of such ages as the Permian and the Trias apply also to the earlier Tertiary; and as the continents, notwithstanding some dips under water, have retained their present forms since the beginning of the Tertiary, it follows that these beds are more definitely related to existing geographical conditions than are those of the older periods, and that the more extensive marine deposits of the Tertiary are, to a great extent, unknown to us. This has naturally led to some difficulty in the classification of Neozoic deposits—those of some of the Tertiary ages being very patchy and irregular, while others spread very widely. In consequence of this, Sir Charles Lyell, to whom we owe very much of our definite knowledge of this period, has proposed a subdivision based on the percentage of recent and fossil animals. In other words, he takes it for granted that a deposit which contains more numerous species of animals still living than another, may be judged on that account to be

more recent. Such a mode of estimation is, no doubt, to some extent arbitrary; but in the main, when it can be tested by the superposition of deposits, it has proved itself reliable. Further, it brings before us this remarkable fact, that while in the older periods all the animals whose remains we find are extinct as species, so soon as we enter on the Neozoic we find some which still continue to our time—at first only a very few, but in later and later beds in gradually increasing percentage, till the fossil and extinct wholly disappear in the recent and living.

The Lyellian classification of the Tertiary will therefore stand as in the following table, bearing in mind that the percentage of fossils is taken from marine forms, and mainly from mollusks, and that the system has in some cases been modified by stratigraphical evidence:—

Tertiary, or Neozoic Time.	}	POST-PLIOCENE, including that which immediately precedes the Modern. In this the shells, etc., are recent, the Mammalia in part extinct.
		PLIOCENE, or more recent age. In this the majority of shells found are recent in the upper beds. In the lower beds the extinct become predominant.
		MIOCENE, or less recent. In this the large majority of shells found are extinct.
		EOCENE, the dawn of the recent. In this only a few recent shells occur.

If we attempt to divide the Tertiary time into ages corresponding to those of the older times, we are met

by the difficulty that as the continents have retained their present forms and characters to a great extent throughout this time, we fail to find those evidences of long-continued submergences of the whole continental plateaus, or very large portions of them, which we have found so very valuable in the Palæozoic and Mesozoic. In the Eocene, however, we shall discover one very instructive case in the great Nummulitic Limestone. In the Miocene and Pliocene the oscillations seem to have been slight and partial. In the Post-pliocene we have the great subsidence of the glacial drift; but that seems to have been a comparatively rapid dip, though of long duration when measured by human history; not allowing time for the formation of great limestones, but only of fossiliferous sands and clays, which require comparatively short time for their deposition. If then we ask as to the duration of the Neozoic, I answer that we have not a definite measure of its ages, if it had any; and that it is possible that the Neozoic may have as yet had but one age, which closed with the great drift period, and that we are now only in the beginning of its second age. Some geologists, impressed with this comparative shortness of the Tertiary, connect it with Mesozoic, grouping both together. This, however, is obviously unnatural. The Mesozoic time certainly terminated with the Cretaceous, and what follows belongs to a distinct æon.

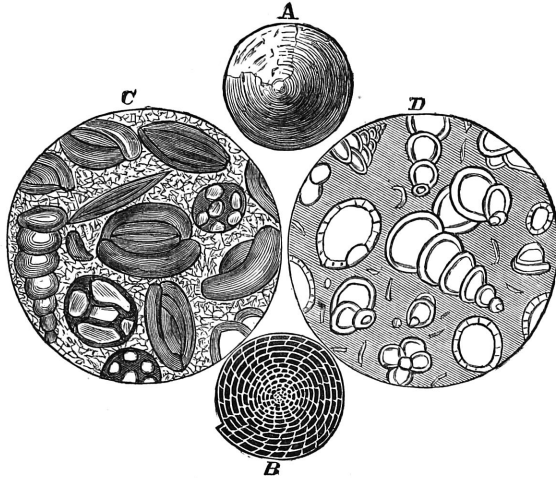
But we must now try to paint the character of this new and peculiar time; and this may perhaps be best

done in the following sketches: 1. The seas of the Eocene. 2. Mammals from the Eocene to the Modern. 3. Tertiary floras. 4. The Glacial period. 5. The Advent of Man.

The great elevation of the continents which closed the Cretaceous was followed by a partial and unequal subsidence, affecting principally the more southern parts of the land of the northern hemisphere. Thus, a wide sea area stretched across all the south of Europe and Asia, and separated the northern part of North America from what of land existed in the southern hemisphere. This is the age of the great Nummulitic Limestones of Europe, Africa, and Asia, and the Orbitoidal Limestones of North America. The names are derived from the prevalence of certain forms of those humble shell-bearing protozoa which we first met with in the Laurentian, and which we have found to be instrumental in building up the chalk, the *Foraminifera* of zoologists. (Fig. p. 243.) But in the Eocene the species of the chalk were replaced by certain broad flat forms, the appearance of which is expressed by the term nummulite, or money-stone; the rock appearing to be made up of fossils, somewhat resembling shillings, sixpences, or three-penny pieces, according to the size of the shells, each of which includes a vast number of small concentric chambers, which during life were filled with the soft jelly of the animal. The nummulite limestone was undoubtedly oceanic, and the other shells contained in it are marine species. After what we have already

seen we do not need this limestone to convince us of the continent-building powers of the oceanic protozoa; but the distribution of these limestones, and the elevation which they attain, furnish the most striking proofs that we can imagine of the changes which the earth's crust has undergone in times geologically modern, and also of the extreme newness of man and his works. Large portions of those countries which constitute the earliest seats of man in Southern Europe, Northern Africa, and Western and Southern Asia, are built upon the old nummulitic sea-bottom. The Egyptians and many other ancient nations quarried it for their oldest buildings. In some of these regions it attains a thickness of several thousand feet, evidencing a lapse of time in its accumulation equal to that implied in the chalk itself. In the Swiss Alps it reaches a height above the sea of 10,000 feet, and it enters largely into the structure of the Carpathians and Pyrenees. In Thibet it has been observed at an elevation of 16,500 feet above the sea. Thus we learn that at a time no more geologically remote than the Eocene Tertiary, lands now of this great elevation were in the bottom of the deep sea; and this not merely for a little time, but during a time sufficient for the slow accumulation of hundreds of feet of rock, made up of the shells of successive generations of animals. If geology presented to us no other revelation than this one fact, it would alone constitute one of the most stupendous pictures in physical geography which could be presented to the imagination. I beg

leave here to present to the reader a little illustration of the limestone-making Foraminifera of the Creta-



FORAMINIFERAL ROCK-BUILDERS.

- A. *Nummulites lævigata*—Eocene.
 B. The same, showing chambered interior.
 C. Milioline limestone, magnified—Eocene, Paris.
 D. Hard Chalk, section magnified—Cretaceous.

ceous and Eocene seas. In the middle above is a nummulite of the natural size. Below is another, sliced to show its internal chambers. At one side is a magnified section of the common building stone of Paris, the milioline limestone of the Eocene, so called from its immense abundance of microscopic shells of the genus *Miliolina*. At the other side is a magnified section of one of the harder varieties of chalk, ground so thin as to become transparent,* and mounted in Canada balsam. It shows many microscopic cham-

* As for instance that of the Giant's Causeway, Antrim.

bered shells of Foraminifera. These may serve as illustrations of the functions of these humble inhabitants of the sea as accumulators of calcareous matter. It is further interesting to remark that some of the beds of nummulitic limestone are so completely filled with these shells, that we might from detached specimens suppose that they belonged to sea-bottoms whereon no other form of life was present. Yet some beds of this age are remarkably rich in other fossils. Lyell states that as many as six hundred species of shells have been found in the principal limestone of the Paris basin alone; and the lower Eocene beds afford remains of fishes, of reptiles, of birds, and of mammals. Among the latter are the bones of gigantic whales, of which one of the most remarkable is the *Zeuglodon* of Alabama, a creature sometimes seventy feet in length, and which replaces in the Tertiary the great *Elasmosaurs* and *Ichthyosaurs* of the Mesozoic, marking the advent, even in the sea, of the age of Mammals as distinguished from the age of Reptiles.

This fact leads us naturally to consider in the second place the mammalia, and other land animals of the Tertiary. At the beginning of the period we meet with that higher group of mammals, not pouched, which now prevails. Among the oldest of these Tertiary beasts are *Coryphodon*, an animal related to the Modern Tapirs, and *Arctocyon*, a creature related to the bears and racoons. These animals represent respectively the *Pachyderms*, or thick-skinned mammals, and the ordinary *Carnivora*. Contemporary with

or shortly succeeding these, were species representing the Rodents, or gnawing animals, and many other creatures of the group Pachydermata, allied to the Modern Tapirs and Hogs, as well as several additional carnivorous quadrupeds. Thus at the very beginning of the Tertiary period we enter on the age of mammals. It may be well, however, to take these animals somewhat in chronological order.

If the old Egyptian, by quarrying the nummulite limestone, bore unconscious testimony to the recent origin of man (whose remains are wholly absent from the Tertiary deposits), so did the ancient Britons and Gauls, when they laid the first rude foundations of future capitals on the banks of the Thames and of the Seine. Both cities lie in basins of Eocene Tertiary, occupying hollows in the chalk. Under London there is principally a thick bed of clay, the "London clay," attaining a thickness of five hundred feet. This bed is obviously marine, containing numerous species of sea shells; but it must have been deposited near land, as it also holds many fossil fruits and other remains of plants to which we shall refer in the sequel, and the bones of several species of large animals. Among these the old reptiles of the Mesozoic are represented by the vertebræ of a supposed "sea snake" (*Palæophis*) thirteen feet long, and species of crocodile allied both to the alligators and the gavials. But besides these there are bones of several animals allied to the hog and tapir, and also a species of opossum. These remains must be drift carcasses from neighbour-

ing shores, and they show first the elevation of the old deep-sea bottom represented by the chalk, so that part of it became dry land ; next, the peopling of that land by tribes of animals and plants unknown to the Mesozoic ; and lastly, that a warm climate must have existed, enabling England at this time to support many types of animals and plants now proper to intertropical regions. As Lyell well remarks, it is most interesting to observe that these beds belong to the beginning of the Tertiary, that they are older than those great nummulite limestones to which we have referred, and that they are older than the principal mountain chains of Europe and Asia. They show that no sooner was the Cretaceous sea dried from off the new land, than there were abundance of animals and plants ready to occupy it, and these not the survivors of the flora and fauna of the Wealden, but a new creation. The mention of the deposit last named places this in a striking light. We have seen that the Wealden beds, under the chalk, represent a Mesozoic estuary, and in it we have the remains of the animals and plants of the land that then was. The great Cretaceous subsidence intervened, and in the London clay we have an estuary of the Eocene. But if we pass through the galleries of a museum where these formations are represented, though we know that both existed in the same locality under a warm climate, we see that they belong to two different worlds, the one to that of the Dinosaurs, the Ammonites, the Cycads, and the minute Marsupials of the Mesozoic, the other to that of the Pachyderms, the Palms, and the Nautili of the Tertiary.

The London clay is lower Eocene; but in the beds of the Isle of Wight and neighbouring parts of the South of England, we have the middle and upper members of the series. They are not, however, so largely developed as in the Paris basin, where, resting on the equivalent of the London clay, we have a thick marine limestone, the Calcaire Grossier, abounding in marine remains, and in some beds composed of shells of foraminifera. The sea in which this limestone was deposited, a portion no doubt of the great Atlantic area of the period, became shallow, so that beds of sand succeeded those of limestone, and finally it was dried up into lake basins, in which gypsum, magnesian sediments, and siliceous limestone were deposited. These lakes or ponds must at some period have resembled the American "salt-licks," and were no doubt resorted to by animals from all the surrounding country in search of the saline mud and water which they afforded. Hence in some marly beds intervening between the layers of gypsum, numerous footprints occur, exactly like those already noticed in the Trias. Had there been a Nimrod in those days to watch with bow or boomerang by the muddy shore, he would have seen herds of heavy short-legged and three-hoofed monsters (Palæotherium), with large heads and long snouts, probably scantily covered with sleek hair, and closely resembling the Modern Tapirs of South America and India, laboriously wading through the mud, and grunting with indolent delight as they rolled themselves in the cool saline slime. Others more light and

graceful, combining some features of the antelope with those of the Tapir (*Anoplotherium*) ran in herds over the drier ridges, or sometimes timidly approached the treacherous clay, tempted by the saline waters. Other creatures representing the Modern Damans or Conies—"feeble folk" which, with the aspect of hares, have the structure of *Pachyderms*—were also present. Creatures of these types constituted the great majority of the animals of the Parisian Eocene lakes; but there were also Carnivorous animals allied to the *hyæna*, the wolf, and the opossum, which prowled along the shores by night to seize unwary wanderers, or to prey on the carcasses of animals mired in the sloughs. Wading birds equal in size to the ostrich also stalked through the shallows, and tortoises crawled over the mud.

Lyell mentions the discovery of some bones of one of these gigantic birds (*Gastornis*) in a bed of the rolled chalk flints which form the base of the Paris series, resting immediately on the chalk; one of the first inhabitants perhaps to people some island of chalk just emerged from the waters, and under which lay the bones of the mighty Dinosaurs, and in which were embedded those of sea birds that had ranged, like the albatross and petrel, over the wide expanse of the Cretaceous ocean. These waders, however, like the tortoises and crocodiles and small marsupial mammals, form a link of connection in type at least between the Eocene and the Cretaceous, for bones of wading birds have been found in the Greensands

indicating their existence before the close of the Mesozoic.

The researches of Baron Cuvier in the bones collected in the quarries of Montmartre were regarded as an astonishing triumph of comparative anatomy; and familiar as we now are with similar and yet more difficult achievements, we can yet afford to regard with admiration the work of the great French naturalist as it is recorded in its collected form in his "Recherches sur les Ossemens Fossiles," published in 1812. His clear and philosophical views as to the plan perceptible in nature, his admirable powers of classification, his acute perception of the correlation of parts in animals, his nice discrimination of the resemblances and differences of fossil and recent structures, and of the uses of these,—all mark him as one of the greatest minds ever devoted to the study of natural science. It is obvious, that had his intellect been occupied by the evolutionist metaphysics which pass for natural science with too many in our day, he would have effected comparatively little; and instead of the magnificent museum in the "Règne Animal" and the "Ossemens Fossiles," we might have had wearisome speculations on the derivation of species. It is reason for profound thankfulness that it was not so; and also that so many great observers and thinkers of our day, like Sedgwick, Murchison, Lyell, Owen, Dana, and Agassiz, have been allowed to work out their researches almost to completion before the advent of those poisoned

streams and mephitic vapours which threaten the intellectual obscuration of those who should be their successors.

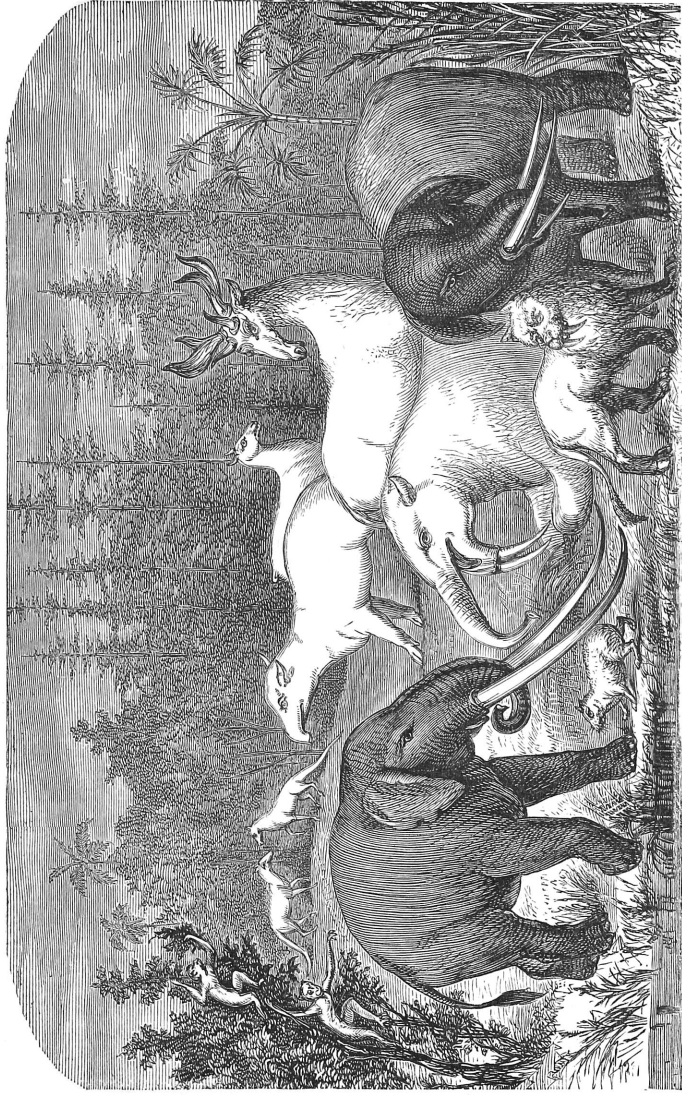
If we pass from the Eocene to the Miocene, still confining ourselves mainly to mammalian life, we find three remarkable points of difference—(1) Whereas the Eocene mammals are remarkable for adherence to one general type, viz., that group of pachyderms most regular and complete in its dentition, we now find a great number of more specialised and peculiar forms; (2) We find in the latter period a far greater proportion of large carnivorous animals; (3) We find much greater variety of mammals than either in the Eocene or the Modern, and a remarkable abundance of species of gigantic size. The Miocene is thus apparently the culminating age of the mammalia, in so far as physical development is concerned; and this, as we shall find, accords with its remarkably genial climate and exuberant vegetation.

In Europe, the beds of this age present, for the first time, examples of the monkeys, represented by two generic types, both of them apparently related to the modern long-armed species, or Gibbons. Among carnivorous animals we have cat-like creatures, one of which is the terrible *Machairodus*, distinguished from all modern animals of its group by the long sabre-shaped canines of its upper jaw, fitting it to pull down and destroy those large pachyderms which could have easily shaken off a lion or a tiger. Here also we have the elephants, represented by

several species now extinct; the mastodon, a great, coarsely-built, hog-like elephant, some species of which had tusks both in the upper and lower jaw; the rhinoceros, the hippopotamus, and the horse, all of extinct species. We have also giraffes, stags, and antelopes, the first ruminants known to us, and a great variety of smaller and less noteworthy creatures. Here also, for the first time, we find the curious and exceptional group of Edentates, represented by a large ant-eater. Of all the animals of the European Miocene, the most wonderful and unlike any modern beast, is the Dinotherium, found in the Miocene of Epplesheim in Germany; and described by Kaup. Some doubt rests on the form and affinities of the animal; but we may reasonably take it, as restored by its describer, and currently reproduced in popular books, to have been a quadruped of somewhat elephantine form. Some years ago, however, a huge haunch bone, supposed to belong to this creature, was discovered in the South of France; and from this it was inferred that the Dinothere may have been a marsupial or pouched animal, perhaps allied in form and habits to the kangaroos. The skull is three feet four inches in length; and when provided with its soft parts, including a snout or trunk in front, it must have been at least five or six feet long. Such a head, if it belonged to a quadruped of ordinary proportions, must represent an animal as large in proportion to our elephant as an elephant to an ox. But its size

is not its most remarkable feature. It has two large tusks firmly implanted in strong bony sockets; but they are attached to the end of the lower jaw and point downward at right angles to it, so that the lower jaw forms a sort of double-pointed pickaxe of great size and strength. This might have been used as a weapon; or, if the creature was aquatic, as a grappling iron to hold by the bank, or by floating timber; but more probably it was a grubbing-hoe for digging up roots or loosening the bases of trees which the animal might afterward pull down to devour them. However this may be, the creature laboured under the mechanical disadvantage of having to lift an immense weight in the process of mastication, and of being unable to bring its mouth to the ground, or to bite or grasp anything with the front of its jaws. To make up for this, it had muscles of enormous power on the sides of the head attached to great projecting processes; and it had a thick but flexible proboscis, to place in its mouth the food grubbed up by its tusks. Taken altogether, the Dinotherium is perhaps the most remarkable of mammals, fossil or recent; and if the rest of its frame were as extraordinary as its skull, we have probably as yet but a faint conception of its peculiarities. We may apply to it, with added force, the admiring ejaculation of Job, when he describes the strength of the hippopotamus, "He is the chief of the ways of God. He who made him, gave him his sword."

In Asia, the Siwalik hills afforded to Falconer and



MIOCENE MAMMALS OF THE EASTERN CONTINENT.

In the foreground *Elephas Gansseri*, *Hyrcotherium*, *Dinotherium*, *Mastotherium*, *Mastodon longirostris*. In the middle distance, Apes, two *Amphotheres*, *Palaeotherium*, *Xiphodon*, and *Sivatherium*. Sequoias and Fan Palm in the background.

Cautley one of the most remarkable exhibitions of Miocene animals in the world. These hills form a ridge subordinate to the Himalayan chain; and rise to a height of 2,000 to 3,000 feet. In the Miocene period, they were sandy and pebbly shores and banks lying at the foot of the then infant Himalayas, which, with the table-lands to the north, probably formed a somewhat narrow east and west continental mass or large island. As a mere example of the marvellous fauna which inhabited this Miocene land, it has afforded remains of seven species of elephants, mastodons, and allied animals; one of them, the *E. Ganesa*, with tusks ten feet and a half long, and twenty-six inches in circumference at the base. Besides these there are five species of rhinoceros, three of horse and allied animals, four or more of hippopotamus, and species of camel, giraffe, antelope, sheep, ox, and many other genera, as well as numerous large and formidable beasts of prey. There is also an ostrich; and, among other reptiles, a tortoise having a shell twelve feet in length, and this huge roof must have covered an animal eighteen feet long and seven feet high. Among the more remarkable of the Siwalik animals is the *Sivatherium*, a gigantic four-horned antelope or deer, supposed to have been of elephantine size, and of great power and swiftness; and to have presented features connecting the ruminants and pachyderms. Our restoration of this creature is to some extent conjectural; and a remarkably artistic, and probably more accurate, restoration of the

animal has recently been published by Dr. Murie, in the Geological Magazine. We justly regard the Mammalian fauna of modern India as one of the noblest in the world; but it is paltry in comparison with that of the much more limited Miocene India; even if we suppose, contrary to all probability, that we know most of the animals of the latter. But if we consider the likelihood that we do not yet know a tenth of the Miocene animals, the contrast becomes vastly greater.

Miocene America is scarcely behind the Old World in the development of its land animals. From one locality in Nebraska, Leidy described in 1852 fifteen species of large quadrupeds; and the number has since been considerably increased. Among these are species of *Rhinoceros*, *Palæotherium*, and *Machairodus*; and one animal, the *Titanotherium*, allied to the European *Anoplothere*, is said to have attained a length of eighteen feet and a height of nine, its jaws alone being five feet long.

In the illustration, I have grouped some of the characteristic Mammalian forms of the Miocene, as we can restore them from their scattered bones, more or less conjecturally; but could we have seen them march before us in all their majesty, like the Edenic animals before Adam, I feel persuaded that our impressions of this wonderful age would have far exceeded anything that we can derive either from words or illustrations. I insist on this the more that the Miocene happens to be very slenderly

represented in Britain; and scarcely at all in north-eastern America; and hence has not impressed the imagination of the English race so strongly as its importance justifies.

The next succeeding period, that of the Pliocene, continues the conditions of the last, but with signs of decadence. Many of the old gigantic pachyderms have disappeared; and in their stead some familiar modern genera were introduced. The Pliocene was terminated by the cold or glacial period, in which a remarkable lowering of temperature occurred over all the northern hemisphere, accompanied, at least in a portion of the time, by a very general and great subsidence, which laid all the lower parts of our continents under water. This terminated much of the life of the Pliocene, and replaced it with boreal and Arctic forms, some of them, like the great hairy Siberian mammoth and the woolly rhinoceros, fit successors of the gigantic Miocene fauna. How it happened that such creatures were continued during the Post-pliocene cold, we cannot understand till we have the Tertiary vegetation before us. It must suffice now to say, that as the temperature was modified, and the land rose, and the Modern period was inaugurated, these animals passed away, and those of the present time remained.

Perhaps the most remarkable fact connected with this change, is that stated by Pictet, that all the modern European mammals are direct descendants of Post-pliocene species; but that in the Post-plio-

cene they were associated with many other species; and these, often of great dimensions, now extinct. In other words, the time from the Pliocene to the Modern, has been a time of diminution of species, while that from the Eocene to the Miocene was a time of rapid introduction of new species. Thus the Tertiary fauna culminated in the Miocene. Yet, strange though this may appear, Man himself, the latest and noblest of all, would seem to have been a product of the later stages of the time of decadence. I propose, however, to return to the animals immediately preceding man and his contemporaries, after we have noticed the Tertiary flora and the Glacial period.

CHAPTER XI.

THE NEOZOIC AGES—(*continued*).

PLANT-LIFE in the Tertiary approaches very nearly to that of the Modern World, in so far as its leading types are concerned; but in its distribution geographically it was wonderfully different from that with which we are at present familiar. For example, in the Isle of Sheppey, at the mouth of the Thames, are beds of "London clay," full of fossil nuts; and these, instead of being hazel nuts and acorns, belong to palms allied to species now found in the Philippine Islands and Bengal, while with them are numerous cone-like fruits belonging to the Proteaceæ (banksias, silver-trees, wagenbooms, etc.), a group of trees now confined to Australia and South Africa, but which in the Northern Hemisphere had already, as stated in a previous paper, made their appearance in the Cretaceous, and were abundant in the Eocene. The state of preservation of these fruits shows that they were not drifted far; and in some beds in Hampshire, also of Eocene age, the leaves of similar plants occur along with species of fig, cinnamon, and other forms equally Australian or Indian. In America, especially in the west, there are thick and widely-distributed beds of lignite or imperfect coal of the Eocene period; but the plants found

in the American Eocene are more like those of the European Miocene or the Modern American flora, a fact to which we must revert immediately.

In Europe, while the Eocene plants resemble those of Australia, when we ascend into the Miocene they resemble those of America, though still retaining some of the Australian forms. In the leaf-beds of the Isle of Mull,—where beds of vegetable mould and leaves were covered up with the erupted matter of a volcano belonging to a great series of such eruptions which produced the basaltic cliffs of Antrim and of Staffa,—and at Bovey, in Devonshire, where Miocene plants have accumulated in many thick beds of lignite, the prevailing plants are sequoias or red-woods, vines, figs, cinnamons, etc. In the sandstones at the base of the Alps similar plants and also palms of American types occur. In the Upper Miocene beds of Cœningen in the Rhine valley, nearly five hundred species of plants have been found, and include such familiar forms as the maples, plane-trees, cypress, elm, and sweet-gum, more American, however, than European in their aspect. It thus appears that the Miocene flora of Europe resembles that of America at present, while the Eocene flora of Europe resembles that of Australia, and the Eocene flora of America, as well as the modern, resembles the Miocene of Europe. In other words, the changes of the flora have been more rapid in Europe than in America and probably slowest of all in Australia. The Eastern Continent has thus taken the lead in rapidity of

change in the Tertiary period, and it has done so in animals as well as in plants.

The following description of the flora of Bovey is given, with slight alteration, in the words of Dr. Heer, in his memoir on that district. The woods that covered the slopes consisted mainly of a huge pine-tree (sequoia), whose figure resembled in all probability its highly-admired cousin, the giant *Wellingtonia* of California. The leafy trees of most frequent occurrence were the cinnamon and an ever-green oak like those now seen in Mexico. The ever-green figs, the custard apples, and allies of the Cape jasmine, were rarer. The trees were festooned with vines, beside which the prickly rotang palm twined its snake-like form. In the shade of the forest throve numerous ferns, one species of which formed trees of imposing grandeur, and there were masses of under-wood belonging to various species of *Nyssa*, like the tupelos and sour-gums of North America. This is a true picture, based on actual facts, of the vegetation of England in the Miocene age.

But all the other wonders of the Miocene flora are thrown into the shade by the discoveries of plants of this age which have recently been made in Greenland, a region now bound up in what we poetically call eternal ice, but which in the Miocene was a fair and verdant land, rejoicing in a mild climate and rich vegetation. The beds containing these specimens occur in various places in North Greenland; and the principal locality, Atane-Kerdruk, is in lat. 70 N.,

and at an elevation of more than a thousand feet above the sea. The plants occur abundantly in sandstone and clay beds, and the manner in which delicate leaves and fruits are preserved shows that they have not been far water-borne, a conclusion which is confirmed by the occurrence of beds of lignite of considerable thickness, and which are evidently peaty accumulations containing trunks of trees. The collections made have enabled Heer to catalogue 137 species, all of them of forms proper to temperate, or even warm regions, and mostly American in character. As many as forty-six of the species already referred to as occurring at Bovey Tracey and Eningen occur also in the Greenland beds. Among the plants are many species of pines, some of them of large size; and the beeches, oaks, planes, poplars, maples, walnuts, limes, magnolias, and vines are apparently as well represented as in the warm temperate zone of America at the present day. This wonderful flora was not a merely local phenomenon, for similar plants are found in Spitzbergen in lat. $78^{\circ} 56'$. It is to be further observed, that while the general characters of these ancient Arctic plants imply a large amount of summer heat and light, the evergreens equally imply a mild winter. Further, though animal remains are not found with these plants, it is probable that so rich a supply of vegetable food was not unutilised, and that we shall some time find that there was an Arctic fauna corresponding to the Arctic flora. How such a climate could exist in Greenland and Spitzbergen is

still a mystery. It has, however, been suggested that this effect might result from the concurrence of such astronomical conditions in connection with the eccentricity of the earth's orbit as would give the greatest amount of warmth in the Northern Hemisphere with such distribution of land and water as would give the least amount of cold northern land and the most favourable arrangement of the warm surface currents of the ocean.*

Before leaving these Miocene plants, I must refer to a paragraph which Dr. Heer has thought it necessary to insert in his memoir on the Greenland flora, and which curiously illustrates the feebleness of what with some men passes for science. He says: "In conclusion; I beg to offer a few remarks on the amount of certainty in identification which the determination of fossil plants is able to afford us. We know that the flowers, fruits, and seeds are more important as characteristics than the leaves. There are many genera of which the leaves are variable, and consequently would be likely to lead us astray if we trusted in them alone. However, many characters of the form and venation of leaves are well-known to be characteristic of certain genera, and can therefore afford us characters of great value for their recognition." In a similar apologetic style he proceeds through several sentences to plead the cause of his Greenland leaves. That he should have to do so is strange, unless indeed the botany known to those for

* Croll and Lyell.

whom he writes is no more than that which a school-girl learns in her few lessons in dissecting a buttercup or daisy. It is easy for scientific triflers to exhibit collections of plants in which species of different genera and families are so similar in their leaves that a careless observer would mistake one for the other, or to get up composite leaves in part of one species and in part of another, and yet seeming the same, and in this way to underrate the labours of painstaking observers like Heer. But it is nevertheless true that in any of these leaves, not only are there good characters by which they can be recognised, but that a single breathing pore, or a single hair, or a few cells, or a bit of epidermis not larger than a pin's head, should enable any one who understands his business to see as great differences as a merely superficial botanist would see between the flower of a ranunculus and that of a strawberry. Heer himself, and the same applies to all other competent students of fossil plants, has almost invariably found his determinations from mere fragments of leaves confirmed when more characteristic parts were afterwards discovered. It is high time, in the interests of geology, that botanists should learn that constancy and correlation of parts are laws in the plant as well as in the animal; and this they can learn only by working more diligently with the microscope. I would, however, go further than this, and maintain that, in regard to some of the most important geological conclusions to be derived from fossils, even the leaves of plants are vastly more

valuable than the hard parts of animals. For instance, the bones of elephants and rhinoceroses found in Greenland would not prove a warm climate; because the creatures might have been protected from cold with hair like that of the musk-sheep, and they might have had facilities for annual migrations like the bisons. The occurrence of bones of reindeer in France does not prove that its climate was like that of Lapland; but only that it was wooded, and that the animals could rove at will to the hills and to the coast. But, on the other hand, the remains of an evergreen oak in Greenland constitute absolute proof of a warm and equable climate; and the occurrence of leaves of the dwarf birch in France constitutes a proof of a cool climate, worth more than that which can be derived from the bones of millions of reindeer and musk-sheep. Still further, in all those greater and more difficult questions of geology which relate to the emergence and submergence of land areas, and to the geographical conditions of past geological periods, the evidence of plants, especially when rooted in place, is of far more value than that of animals, though it has yet been very little used.

This digression prepares the way for the question: Was the Miocene period on the whole a better age of the world than that in which we live? In some respects it was. Obviously there was in the Northern Hemisphere a vast surface of land under a mild and equable climate, and clothed with a rich and varied vegetation. Had we lived in the Miocene, we might

have sat under our vine and fig-tree equally in Greenland and Spitzbergen and in those more southern climes to which this privilege is now restricted. We might have enjoyed a great variety of rich and nutritive fruits, and, if sufficiently muscular, and able to cope with the gigantic mammals of the period, we might have engaged in either the life of the hunter or that of the agriculturist under advantages which we do not now possess. On the whole, the Miocene presents to us in these respects the perfection of the Neozoic time, and its culmination in so far as the nobler forms of brute animals and of plants are concerned. Had men existed in those days, however, they should have been, in order to suit the conditions surrounding them, a race of giants; and they would probably have felt the want of many of those more modern species belonging to the flora and fauna of Europe and Western Asia on which man has so much depended for his civilization. Some reasons have been adduced for the belief that in the Miocene and Eocene there were intervals of cold climate; but the evidence of this may be merely local and exceptional, and does not interfere with the broad characteristics of the age as sketched above.

The warm climate and rich vegetation of the Miocene extended far into the Pliocene, with characters very similar to those already stated; but as the Pliocene age went on, cold and frost settled down upon the Northern Hemisphere, and a remarkable change took place in its vegetable productions. For

example, in the somewhat celebrated "forest bed" of Cromer, in Norfolk, which is regarded as Newer Pliocene, we have lost all the foreign and warm-climate plants of the Miocene, and find the familiar Scotch firs and other plants of the Modern British flora. The animals, however, retain their former types; for two species of elephant, a hippopotamus, and a rhinoceros are found in connection with these plants. This is another evidence, in addition to those above referred to, that plants are better thermometers to indicate geological and climatal change than animals. This Pliocene refrigeration appears to have gone on increasing into the next or Post-pliocene age, and attained its maximum in the Glacial period, when, as many geologists think, our continents were, even in the temperate latitudes, covered with a sheet of ice like that which now clothes Greenland. Then occurred a very general subsidence, in which they were submerged under the waters of a cold icy sea, tenanted by marine animals now belonging to boreal and arctic regions. After this last great plunge-bath they rose to constitute the dry land of man and his contemporaries. Let us close this part of the subject with one striking illustration from Heer's memoir on Bovey Tracey. At this place, above the great series of clays and lignites containing the Miocene plants already described, is a thick covering of clay, gravel, and stones, evidently of much later date. This also contains some plants; but instead of the figs, and cinnamons, and evergreen oaks, they are the petty

dwarf birch of Scandinavia and the Highland hills, and three willows, one of them the little Arctic and Alpine creeping willow. Thus we have in the south of England a transition in the course of the Pliocene period, from a climate much milder than that of Modern England to one almost Arctic in its character.

Our next topic for consideration is one of the most vexed questions among geologists, the Glacial period which immediately preceded the Advent of Man. In treating of this it will be safest first to sketch the actual appearances which present themselves, and then to draw such pictures as we can of the conditions which they represent. The most recent and superficial covering of the earth's crust is usually composed of rock material more or less ground up and weathered. This may, with reference to its geological character and origin, be considered as of three kinds. It may be merely the rock weathered and decomposed to a certain extent *in situ*; or it may be alluvial matter carried or deposited by existing streams or tides, or by the rains; or, lastly, it may be material evidencing the operation of causes not now in action. This last constitutes what has been called drift or diluvial detritus, and is that with which we have now to do. Such drift, then, is very widely distributed on our continents in the higher latitudes. In the Northern Hemisphere it extends from the Arctic regions to about 50° of north latitude in Europe, and as low as 40° in North America; and it occurs south of similar parallels in the Southern Hemisphere. Farther

towards the equator than the latitudes indicated, we do not find the proper drift deposits, but merely weathered rocks or alluvia, or old sea bottoms raised up. This limitation of the drift, at the very outset gives it the character of a deposit in some way connected with the Polar cold. Besides this, the general transport of stones and other material in the northern regions has been to the south; hence in the Northern Hemisphere this deposit may be called the *Northern Drift*.

If now we take a typical locality of this formation, such, for instance, as we may find in Scotland, or Scandinavia, or Canada, we shall find it to consist of three members, as follows:—

3. Superficial Sands or Gravels.
2. Stratified Clays.
1. Till or Boulder Clay.

This arrangement may locally be more complicated, or it may be deficient in one of its members. The boulder clay may, for example, be underlaid by stratified sand or gravel, or even by peaty deposits; it may be intermixed with layers of clay or sand; the stratified clay or the boulder clay may be absent, or may be uncovered by any upper member. Still we may take the typical series as above stated, and inquire as to its characters and teaching.

The lower member, or boulder clay, is a very remarkable kind of deposit, consisting of a paste which may graduate from tough clay to loose sand,

and which holds large angular and rounded stones or boulders confusedly intermixed; these stones may be either from the rocks found in the immediate vicinity of their present position, or at great distances. This mass is usually destitute of any lamination or subordinate stratification, whence it is often called *Unstratified Drift*, and is of very variable thickness, often occurring in very thick beds in valleys, and being comparatively thin or absent on intervening hills. Further, if we examine the stones contained in the boulder clay, we shall find that they are often scratched or striated and grooved; and when we remove the clay from the rock surfaces on which it rests, we find these in like manner striated, grooved and polished. These phenomena, viz., of polished and striated rocks and stones, are similar to those produced by those great sliding masses of ice, the glaciers of Alpine regions, which in a small way and in narrow and elevated valleys, act on the rocks and stones in this manner, though they cannot form deposits precisely analogous to the boulder clay, owing to the wasting away of much of the finer material by the torrents, and the heaping of the coarser detritus in ridges and piles. Further, we have in Greenland a continental mass, with all its valleys thus filled with slowly-moving ice, and from this there drift off immense ice-islands, which continue at least the mud-and-stone-depositing process, and possibly also the grinding process, over the sea bottom. So far all geologists are agreed; but here

they diverge into two schools. One of these, that of the Glacier theorists, holds that the boulder clay is the product of land-ice; and this requires the supposition that at the time when it was deposited the whole of our continents north of 40° or 50° was in the condition of Greenland at present. This is, however, a hypothesis so inconvenient, not to say improbable, that many hesitate to accept it, and prefer to believe that in the so-called Glacial period the land was submerged, and that icebergs then as now drifted from the north in obedience to the Arctic currents, and produced the effects observed. It would be tedious to go into all the arguments of the advocates of glaciers and icebergs, and I shall not attempt this, more especially as the only way to decide the question is to observe carefully the facts in every particular locality, and inquire as to the conclusions fairly deducible. With the view of aiding such a solution, however, I may state a few general principles applicable to the appearances observed. We may then suppose that boulder clay may be formed in three ways. (1) It may be deposited on land, as what is called the bottom moraine of a land glacier. (2) It may be deposited in the sea when such a glacier ends on the coast. (3) It may be deposited by the melting or grounding on muddy bottoms of the iceberg masses floated off from the end of such a glacier. It is altogether likely, from the observations recently made in Greenland, that in that country such a deposit is being formed in all

these ways. In like manner, the ancient boulder clay may have been formed in one or more of these ways in any given locality where it occurs, though it may be difficult in many instances to indicate the precise mode. There are, however, certain criteria which may be applied to the determination of its origin, and I may state a few of these, which are the results of my own experience. (1) Where the boulder clay contains marine shells, or rounded stones which if exposed to the air would have been cracked to pieces, decomposed, or oxidized, it must have been formed under water. Where the conditions are the reverse of these, it may have been formed on land. (2) When the striations and transport of materials do not conform to the levels of the country, and take that direction, usually N.E. and S.W., which the Arctic current would take if the country were submerged, the probability is that it was deposited in the sea. Where, however, the striation and transport take the course of existing valleys, more especially in hilly regions, the contrary may be inferred. (3) Where most of the material, more especially the large stones, has been carried to great distances from its original site, especially over plains or up slopes, it has probably been sea-borne. Where it is mostly local, local ice-action may be inferred. Other criteria may be stated, but these are sufficient for our present purpose. Their application in every special case I do not presume to make; but I am convinced that when applied to those regions in Eastern America with which I am

familiar, they necessitate the conclusion that in the period of extreme refrigeration, the greater part of the land was under water, and such hills and mountains as remained were little Greenlands, covered with ice and sending down glaciers to the sea. In hilly and broken regions, therefore, and especially at considerable elevations, we find indications of *glacier* action; on the great plains, on the contrary, the indications are those of *marine* glaciation and transport. This last statement, I believe, applies to the mountains and plains of Europe and Asia as well as of America.

This view requires not only the supposition of great refrigeration, but of a great subsidence of the land in the temperate latitudes, with large residual islands and hills in the Arctic regions. That such subsidence actually took place is proved, not only by the frequent occurrence of marine shells in the boulder clay itself, but also by the occurrence of stratified marine clays filled with shells, often of deep-water species, immediately over that deposit. Further, the shells, and also occasional land plants found in these beds, indicate a cold climate and much cold fresh water pouring into the sea from melting ice and snow. In Canada these marine clays have been traced up to elevations of 600 feet, and in Great Britain deposits of this kind occur on one of the mountains of Wales at the height of 1300 feet above the level of the sea. Nor is it to be supposed that this level marks the extreme height of the Post-pliocene waters, for drift

material not explicable by glaciers, and evidences of marine erosion, occur at still higher levels, and it is natural that on high and exposed points fewer remains of fossiliferous beds should be left than in plains and valleys.

At the present day the coasts of Britain and other parts of Western Europe enjoy an exceptionally warm temperature, owing to the warm currents of the Atlantic being thrown on them, and the warm and moist Atlantic air flowing over them, under the influence of the prevailing westerly winds. These advantages are not possessed by the eastern coast of North America, nor by some deep channels in the sea, along which the cold northern currents flow under the warmer water. Hence these last-mentioned localities are inhabited by boreal shells much farther south than such species extend on the coasts and banks of Great Britain. In the Glacial period this exceptional advantage was lost, and while the American seas, as judged by their marine animals, were somewhat colder than at present, the British seas were proportionally much more cooled down. No doubt, however, there were warmer and colder areas, determined by depth and prevailing currents, and as these changed the position in elevation and subsidence of the land, alternations and even mixtures of the inhabitants of cold and warm water resulted, which have often been very puzzling to geologists.

I have taken the series of drift deposits seen in Britain and in Canada as typical, and the previous

discussion has had reference to them. But it would be unfair not to inform the reader that this succession of deposits after all belongs to the margins of our continents rather than to their great central areas. This is the case at least in North America, where in the region of the great lakes the oldest glaciated surfaces are overlaid by thick beds of stratified clay, without marine fossils, and often without either stones or boulders, though these sometimes occur, especially toward the north. The clay, however, contains drifted fragments of coniferous trees. Above this clay are sand and gravel, and the principal deposit of travelled stones and boulders rests on these. I cannot affirm that a similar succession occurs on the great inland plains of Europe and Asia; but I think it probable that to some extent it does. The explanation of this inland drift by the advocates of a great continental glacier is as follows: (1) In the Pliocene period the continents were higher than at present, and many deep valleys, since filled up, were cut in them. (2) In the Post-pliocene these elevated continents became covered with ice, by the movement of which the valleys were deepened and the surfaces striated. (3) This ice-period was followed by a depression and submergence, in which the clays were deposited, filling up old channels, and much changing the levels of the land. Lastly, as the land rose again from this submergence, sand and gravel were deposited, and boulders scattered over the surface by floating ice.

The advocates of floating ice as distinguished from a continental glacier, merely dispense with the latter, and affirm that the striation under the clay, as well as that connected with the later boulders, is the effect of floating bergs. The occurrence of so much drift wood in the clay favours their view, as it is more likely that there would be islands clothed with trees in the sea, than that these should exist immediately after the country had been mantled in ice. The want of marine shells is a difficulty in either view, but may be accounted for by the rapid deposition of the clay and the slow spreading of marine animals over a submerged continent under unfavourable conditions of climate.

In any case the reader will please observe that theorists must account for both the interior and marginal forms of these deposits. Let us tabulate the facts and the modes of accounting for them.

FACTS OBSERVED.		THEORETICAL VIEWS.	
Inland Plains.	Marginal Areas.	Glacier Theories.	Floating-Ice Theories.
Terraces.	Terraces and Raised Beaches.	Emergence of Modern Land.*	
Travelled Boulders and Glaciated Stones and Rocks. Stratified Sand and Gravel.	Sand and Gravel, with Sea Shells and Boulders.	Shallow Sea and Floating Ice.	
Stratified Clay with Drift Wood, and a few Stones and Boulders. Striated Rocks.	Stratified Clay with Sea Shells. Boulder Clay with or without Sea Shells. Striated Rocks.	Deep Sea and Floating Ice.	
Old channels, indicating a higher level of the land.	Old channels, etc., indicating previous dry land.	Submergence of the land. Great continental mantle of Ice.	Much floating Ice and local Glaciers. Submergence of Pliocene Land.
		Erosion by continental Glacier.	Erosion by atmospheric agencies and accumulation of decomposed rock.

* The phenomena of this period, with reference to rainfall, melting snows, and valley deposits, must be noticed in our next chapter.

This table will suffice at least to reduce the great glacier controversy to its narrowest limits, when we have added the one further consideration that glaciers are the parents of icebergs, and that the question is not of one or the other exclusively, but of the relative predominance of the one or the other in certain given times and places. Both theories admit a great Post-pliocene subsidence. The abettors of glaciers can urge the elevation of the surface, the supposed powers of glaciers as eroding agents, and the transport of boulders. Those whose theoretical views lean to floating ice, believe that they can equally account for these phenomena, and can urge in support of their theory the occurrence of drift wood in the inland clay and boulder clay, and of sea-shells in the marginal clay and boulder clay, and the atmospheric decomposition of rock in the Pliocene period, as a source of the material of the clays, while to similar causes they can attribute the erosion of the deep valleys piled with the Post-pliocene deposits. They can also maintain that the general direction of striation and drift implies the action of sea currents, while they appeal to local glaciers to account for special cases of glaciated rocks at the higher levels.

How long our continental plateaus remained under the icy seas of the Glacial period we do not know. Relatively to human chronology, it was no doubt a long time; but short in comparison with those older subsidences in which the great Palæozoic limestones were produced. At length, however, the change

came. Slowly and gradually, or by intermittent lifts, the land rose; and as it did so, shallow-water sands and gravels were deposited on the surface of the deep-sea clays, and the sides of the hills were cut into inland cliffs and terraces, marking the stages of recession of the waters. At length, when the process was complete, our present continents stood forth in their existing proportions ready for the occupancy of man.

The picture which these changes present to the imagination is one of the most extraordinary in all geological history. We have been familiar with the idea of worlds drowned in water, and the primeval incandescent earth shows us the possibility of our globe being melted with fervent heat; but here we have a world apparently frozen out—destroyed by cold, or doubly destroyed by ice and water. Let us endeavour to realise this revolution, as it may have occurred in any of the temperate regions of the Northern Hemisphere, thickly peopled with the magnificent animals that had come down from the grand old Miocene time. Gradually the warm and equable temperature gives place to cold winters and chilly wet summers. The more tender animals die out, and the less hardy plants begin to be winter-killed, or to fail to perfect their fruits. As the forests are thus decimated, other and hardier species replace those which disappear. The animals which have had to confine themselves to sheltered spots, or which have perished through cold or want of food, are replaced by others migrating from the mountains, or

from colder regions. Some, perhaps, in the course of generations, become dwarfed in stature, and covered with more shaggy fur. Permanent snow at length appears upon the hill-tops, and glaciers plough their way downward, devastating the forests, encroaching on the fertile plains, and at length reaching the heads of the bays and fiords. While snow and ice are thus encroaching from above, the land is subsiding, and the sea is advancing upon it, while great icebergs drifting on the coasts still further reduce the temperature. Torrents and avalanches from the hills carry mud and gravel over the plains. Peat bogs accumulate in the hollows. Glaciers heap up confused masses of moraine, and the advancing sea piles up stones and shingle to be imbedded in mud on its further advance, while boreal marine animals invade the now submerged plains. At length the ice and water meet everywhere, or leave only a few green strips where hardy Arctic plants still survive, and a few well-clad animals manage to protract their existence. Perhaps even these are overwhelmed, and the curtain of the Glacial winter falls over the fair scenery of the Pliocene. In every locality thus invaded by an apparently perpetual winter, some species of land animals must have perished. Others may have migrated to more genial climes, others under depauperated and hardy varietal forms may have continued successfully to struggle for existence. The general result must have been greatly to diminish the nobler forms of life, and to encourage only those fitted

for the most rigorous climates and least productive soils.

Could we have visited the world in this dreary period, and have witnessed the decadence and death of that brilliant and magnificent flora and fauna which we have traced upward from the Eocene, we might well have despaired of the earth's destinies, and have fancied it the sport of some malignant demon; or have supposed that in the contest between the powers of destruction and those of renovation the former had finally gained the victory. We must observe, however, that the suffering in such a process is less than we might suppose. So long as animals could exist, they would continue to enjoy life. The conditions unfavourable to them would be equally or more so to their natural enemies. Only the last survivors would meet with what might be regarded as a tragical end. As one description of animal became extinct, another was prepared to occupy its room. If elephants and rhinoceroses perished from the land, countless herds of walruses and seals took their places. If gay insects died and disappeared, shell-fishes and sea-stars were their successors.

Thus in nature there is life even in death, and constant enjoyment even when old systems are passing away. But could we have survived the Glacial period, we should have seen a reason for its apparently wholesale destruction. Out of that chaos came at length an Eden; and just as the Permian prepared the way for the Mesozoic, so the glaciers and icebergs

of the Post-pliocene were the ploughshare of God preparing the earth for the time when, with a flora and fauna more beautiful and useful, if less magnificent than that of the Tertiary, it became as the garden of the Lord, fitted for the reception of His image and likeness, immortal and intelligent Man. We need not, however, with one modern school of philosophy, regard man himself as but a descendant of Miocene apes, scourged into reason and humanity by the struggle for existence in the Glacial period. We may be content to consider him as a son of God, and to study in the succeeding chapters that renewal of the Post-pliocene world which preceded and heralded his advent.

In the meantime, our illustration,* borrowed in part from the magnificent representation of the Post-pliocene fauna of England, by the great restorer of extinct animals, Mr. Waterhouse Hawkins, may serve to give some idea of the grand and massive forms of animal life which, even in the higher latitudes, survived the Post-pliocene cold, and only decayed and disappeared under that amelioration of physical conditions which marks the introduction of the human period.

* Page 301.

CHAPTER XII.

CLOSE OF THE POST-PLIOCENE, AND ADVENT OF MAN.

IN closing these sketches it may seem unsatisfactory not to link the geological ages with the modern period in which we live; yet, perhaps, nothing is more complicated or encompassed with greater difficulties or uncertainties. The geologist, emerging from the study of the older monuments of the earth's history, and working with the methods of physical science, here meets face to face the archæologist and historian, who have been tracing back in the opposite direction, and with very different appliances, the stream of human history and tradition. In such circumstances conflicts may occur, or at least the two paths of inquiry may refuse to connect themselves without concessions unpleasant to the pursuers of one or both. Further, it is just at this meeting-place that the dim candle of traditional lore is almost burnt out in the hand of the antiquary, and that the geologist finds his monumental evidence becoming more scanty and less distinct. We cannot hope as yet to dispel all the shadows that haunt this obscure domain, but can at least point out some of the paths which traverse it.

In attempting this, we may first classify the time involved as follows:—(1) The earlier Post-pliocene

period of geology may be called the *Glacial* era. It is that of a cold climate, accompanied by glaciation and boulder deposits. (2) The later Post-pliocene may be called the *Post-glacial* era. It is that of re-elevation of the continents and restoration of a mild temperature. It connects itself with the pre-historic period of the archæologist, inasmuch as remains of man and his works are apparently included in the same deposits which hold the bones of Post-glacial animals. (3) The *Modern* era is that of secular human history.

It may be stated with certainty that the Pliocene period of geology affords no trace of human remains or implements; and the same may I think be affirmed of the period of glaciation and subsidence which constitutes the earlier Post-pliocene. With the rise of the land out of the Glacial sea indications of man are believed to appear, along with remains of several mammalian species now his contemporaries. Archæology and geology thus meet somewhere in the pre-historic period of the former, and in the Post-glacial of the latter. Wherever, therefore, human history extends farthest back, and geological formations of the most modern periods exist and have been explored, we may expect best to define their junctions. Unfortunately it happens that our information on these points is still very incomplete and locally limited. In many extensive regions, like America and Australia, while the geological record is somewhat complete, the historic record extends back at most a few centuries, and the

pre-historic monuments are of uncertain date. In other countries, as in Western Asia and Egypt, where the historic record extends very far back, the geology is less perfectly known. At the present moment, therefore, the main battle-field of these controversies is in Western Europe, where, though history scarce extends farther back than the time of the Roman Republic, the geologic record is very complete, and has been explored with some thoroughness. It is obvious, however, that we thus have to face the question at a point where the pre-historic gap is necessarily very wide.

Taking England as an example, all before the Roman invasion is pre-historic, and with regard to this pre-historic period the evidence that we can obtain is chiefly of a geological character. The pre-historic men are essentially fossils. We know of them merely what can be learned from their bones and implements embedded in the soil or in the earth of the caverns in which some of them sheltered themselves. For the origin and date of these deposits the antiquary must go to the geologist, and he imitates the geologist in arranging his human fossils under such names as the "Palæolithic," or period of rude stone implements; the "Neolithic," or period of polished stone implements; the Bronze Period, and the Iron Period; though inasmuch as higher and lower states of the arts seem always to have coexisted, and the time involved is comparatively short, these periods are of

far less value than those of geology. In Britain the age of iron is in the main historic. That of bronze goes back to the times of early Phœnician trade with the south of England. That of stone, while locally extending far into the succeeding ages, reaches back into an unknown antiquity, and is, as we shall see in the sequel, probably divided into two by a great physical change, though not in the abrupt and arbitrary way sometimes assumed by those who base their classification solely on the rude or polished character of stone implements. We must not forget, however, that in Western Asia the ages of bronze and iron may have begun two thousand years at least earlier than in Britain, and that in some parts of America the Palæolithic age of chipped stone implements still continues. We must also bear in mind that when the archæologist appeals to the geologist for aid, he thereby leaves that kind of investigation in which dates are settled by years, for that in which they are marked merely by successive physical and organic changes.

Turning, then, to our familiar geological methods, and confining ourselves mainly to the Northern Hemisphere and to Western Europe, two pictures present themselves to us: (1) The physical changes preceding the advent of man; (2) The decadence of the land animals of the Post-pliocene age, and the appearance of those of the modern.

In the last chapter I had to introduce the reader

to a great and terrible revolution, whereby the old Pliocene continents, with all their wealth of animals and plants, became sealed up in a mantle of Greenland ice, or, slowly sinking beneath the level of the sea, were transformed into an ocean-bottom over which icebergs bore their freight of clay and boulders. We also saw that as the Post-pliocene age advanced, the latter condition prevailed, until the waters stood more than a thousand feet deep over the plains of Europe. In this great glacial submergence, which closed the earlier Post-pliocene period, and over vast areas of the Northern Hemisphere, terminated the existence of many of the noblest forms of life, it is believed that man had no share. We have, at least as yet, no record of his presence.

Out of these waters the land again rose slowly and intermittently, so that the receding waves worked even out of hard rocks ranges of coast cliff which the further elevation converted into inland terraces, and that the clay and stones deposited by the Glacial waters were in many places worked over and rearranged by the tides and waves of the shallowing sea before they were permanently raised up to undergo the action of the rains and streams, while long banks of sand and gravel were stretched across plains and the mouths of valleys, constituting "kames," or "eskers," only to be distinguished from moraines of glaciers by the stratified arrangement of their materials.

Further, as the land rose, its surface was greatly and rapidly modified by rains and streams. There is the amplest evidence, both in Europe and America, that at this time the erosion by these means was enormous in comparison with anything we now experience. The rainfall must have been excessive, the volume of water in the streams very great; and the facilities for cutting channels in the old Pliocene valleys, filled to the brim with mud and boulder-clay, were unprecedented. While the area of the land was still limited, much of it would be high and broken, and it would have all the dampness of an insular climate. As it rose in height, plains which had, while under the sea, been loaded with the *débris* swept from the land, would be raised up to experience river erosion. It was the spring-time of the Glacial era, a spring eminent for its melting snows, its rains, and its river floods.* To an observer living at this time it would have seemed as if the slow process of moulding the continents was being pushed forward with unexampled rapidity. The valleys were ploughed out and cleansed, the plains levelled and overspread with beds of alluvium, giving new features of beauty and utility to the land, and preparing the way for the life of the Modern period, as if to make up for the time which had been lost in the dreary Glacial age. It will readily be understood how puzzling these deposits have

* Mr. Tylor has well designated this period as the Pluvial age. *Journal of the Geological Society*, 1870.

been to geologists, especially to those who fail to present to their minds the true conditions of the period; and how difficult it is to separate the river alluvia of this age from the deposits in the seas and estuaries, and these again from the older Glacial beds. Further, in not a few instances the animals of a cold climate must have lived in close proximity to those which belonged to ameliorated conditions, and the fossils of the older Post-pliocene must often, in the process of sorting by water, have been mixed with those of the newer.

Many years ago the brilliant and penetrating intellect of Edward Forbes was directed to the question of the maximum extent of the later Post-pliocene or Post-glacial land; and his investigations into the distribution of the European flora, in connection with the phenomena of submerged terrestrial surfaces, led to the belief that the land had risen until it was both higher and more extensive than at present. At the time of greatest elevation, England was joined to the continent of Europe by a level plain, and a similar plain connected Ireland with its sister islands. Over these plains the plants constituting the "Germanic" flora spread themselves into the area of the British Islands, and herds of mammoth, rhinoceros, and Irish elk wandered and extended their range from east to west. The deductions of Forbes have been confirmed and extended by others; and it can scarcely be doubted that in the Post-glacial era, the land regained fully the extent which it had possessed in the

time of the Pliocene. In these circumstances the loftier hills might still reach the limits of perpetual snow, but their glaciers would no longer descend to the sea. What are now the beds of shallow seas would be vast wooded plains, drained by magnificent rivers, whose main courses are now submerged, and only their branches remain as separate and distinct streams. The cold but equable climate of the Post-pliocene would now be exchanged for warm summers, alternating with sharp winters, whose severity would be mitigated by the dense forest covering, which would also contribute to the due supply of moisture, preventing the surface from being burnt into arid plains.

It seems not improbable that it was when the continents had attained to their greatest extension, and when animal and vegetable life had again overspread the new land to its utmost limits, that man was introduced on the eastern continent, and with him several mammalian species, not known in the Pliocene period, and some of which, as the sheep, the goat, the ox, and the dog, have ever since been his companions and humble allies. These, at least in the west of Europe, were the "Palæolithic" men, the makers of the oldest flint implements; and armed with these, they had to assert the mastery of man over broader lands than we now possess, and over many species of great animals, now extinct. In thus writing, I assume the accuracy of the inferences from the occurrence of worked stones with the bones of

Post-glacial animals, which must have lived during the condition of our continents above referred to. If these inferences are well founded, not only did man exist at this time, but man not even varietally distinct from modern European races. But if man really appeared in Europe in the Post-glacial era, he was destined to be exposed to one great natural vicissitude before his permanent establishment in the world. The land had reached its maximum elevation, but its foundations, "standing in the water and out of the water," were not yet securely settled, and it had to take one more plunge-bath before attaining its modern fixity. This seems to have been a comparatively rapid subsidence and re-elevation, leaving but slender traces of its occurrence, but changing to some extent the levels of the continents, and failing to restore them fully to their former elevation, so that large areas of the lower grounds still remained under the sea. If, as the greater number of geologists now believe, man was then on the earth, it is not impossible that this constituted the deluge recorded in that remarkable "log book" of Noah preserved to us in Genesis, and of which the memory remains in the traditions of most ancient nations. This is at least the geological deluge which separates the Post-glacial period from the Modern, and the earlier from the later pre-historic period of the archæologists.*

* I have long thought that the narrative in Gen. vii. and viii. can be understood only on the supposition that it is a contemporary journal or log of an eye-witness incorporated by

Very important questions of time are involved in this idea of Post-glacial man, and much will depend, in the solution of these, on the views which we adopt as to the rate of subsidence and elevation of the land. If, with the majority of British geologists, we hold that it is to be measured by those slow movements now in progress, the time required will be long. If, with most Continental and some American geologists, we believe in paroxysmal movements of elevation and depression, it may be much reduced. We have seen in the progress of our inquiries that the movements of the continents seem to have occurred with accelerated rapidity in the more modern periods. We have also seen that these movements might depend on the slow contraction of the earth's crust due to cooling, but that the effects of this contraction might manifest themselves only at intervals. We have further seen that the gradual retardation of the rotation of the earth furnishes a cause capable of producing elevation and subsidence of the land, and that this also might be manifested at longer or shorter intervals, according to the strength and resisting power of the crust. Under the influence of this retardation, so long as the crust of the earth did not give way, the waters would be driven toward the poles, and the the author of Genesis in his work. The dates of the rising and fall of the water, the note of soundings over the hill-tops when the maximum was attained, and many other details, as well as the whole tone of the narrative, seem to require this supposition, which also removes all the difficulties of interpretation which have been so much felt.

northern land would be submerged; but so soon as the tension became so great as to rupture the solid shell, the equatorial regions would collapse, and the northern land would again be raised. The subsidence would be gradual, the elevation paroxysmal, and perhaps intermittent. Let us suppose that this was what occurred in the Glacial period, and that the land had attained to its maximum elevation. This might not prove to be permanent; the new balance of the crust might be liable to local or general disturbance in a minor degree, leading to subsidence and partial re-elevation, following the great Post-glacial elevation. There is, therefore, nothing unreasonable in that view which makes the subsidence and re-elevation at the close of the Post-glacial period somewhat abrupt, at least when compared with some more ancient movements.

But what is the evidence of the deposits formed at this period? Here we meet with results most diverse and contradictory, but I think there can be little doubt that on this kind of evidence the time required for the Post-glacial period has been greatly exaggerated, especially by those geologists who refuse to receive such views as to subsidence and elevation as those above stated. The calculations of long time based on the gravels of the Somme, on the cone of the Tinière, on the peat bogs of France and Denmark, on certain cavern deposits, have all been shown to be more or less at fault; and possibly none of these reach further back than the six or seven thousand

years which, according to Dr. Andrews, have elapsed since the close of the boulder-clay deposits in America.* I am aware that such a statement will be regarded with surprise by many in England, where even the popular literature has been penetrated with the idea of a duration of the human period immensely long in comparison with what used to be the popular belief; but I feel convinced that the scientific pendulum must swing backward in this direction nearer to its old position. Let us look at a few of the facts. Much use has been made of the "cone" or delta of the Tinière on the eastern side of the Lake of Geneva, as an illustration of the duration of the Modern period. This little stream has deposited at its mouth a mass of *débris* carried down from the hills. This being cut through by a railway, is found to contain Roman remains to a depth of four feet, bronze implements to a depth of ten feet, stone implements at a depth of nineteen feet. The deposit ceased about three hundred years ago, and calculating 1300 to 1500 years for the Roman period, we should have 7000 to 10,000 years as the age of the cone. But before the formation of the present cone, another had been formed twelve times as large. Thus for the two cones together, a duration of more than 90,000 years is claimed. It appears, however, that this calculation has been made irrespective of two essential elements in the question. No allowance has been made for the fact that the inner layers of a cone are

* "Transactions, Chicago Academy," 1871.

necessarily smaller than the outer ; nor for the further fact that the older cone belongs to a distinct time (the pluvial age already referred to), when the rainfall was much larger, and the transporting power of the torrent great in proportion. Making allowance for these conditions, the age of the newer cone, that holding human remains, falls between 4000 and 5000 years. The peat bed of Abbeville, in the north of France, has grown at the rate of one and a half to two inches in a century. Being twenty-six feet in thickness, the time occupied in its growth must have amounted to 20,000 years ; and yet it is probably newer than some of the gravels on the same river containing flint implements. But the composition of the Abbeville peat shows that it is a forest peat, and the erect stems preserved in it prove that in the first instance it must have grown at the rate of about three feet in a century, and after the destruction of the forest its rate of increase down to the present time diminished rapidly almost to nothing. Its age is thus reduced to perhaps less than 4000 years. In 1865 I had an opportunity to examine the now celebrated gravels of St. Acheul, on the Somme, by some supposed to go back to a very ancient period. With the papers of Prestwich and other able observers in my hand, I could conclude merely that the undisturbed gravels were older than the Roman period, but how much older only detailed topographical surveys could prove ; and that taking into account the probabilities of a different level of the land, a

wooded condition of the country, a greater rainfall, and a glacial filling of the Somme valley with clay and stones subsequently cut out by running water, the gravels could scarcely be older than the Abbeville peat. To have published such views in England would have been simply to have delivered myself into the hands of the Philistines. I therefore contented myself with recording my opinion in Canada. Tylor* and Andrews† have, however, I think, subsequently shown that my impressions were correct.

In like manner, I fail to perceive,—and I think all American geologists acquainted with the pre-historic monuments of the western continent must agree with me,—any evidence of great antiquity in the caves of Belgium and England, the kitchen-middens of Denmark, the rock-shelters of France, the lake habitations of Switzerland. At the same time, I would disclaim all attempt to resolve their dates into precise terms of years. I may merely add, that the elaborate and careful observations of Dr. Andrews on the raised beaches of Lake Michigan,—observations of a much more precise character than any which, in so far as I know, have been made of such deposits in Europe,—enable him to calculate the time which has elapsed since North America rose out of the waters of the Glacial period as between 5500 and 7500 years. This fixes at least the possible duration of the human period in North America, though I believe there are

* "Journal of Geological Society," vol. xxv.

† "Silliman's Journal," 1868.

other lines of evidence which would reduce the residence of man in America to a much shorter time. Longer periods have, it is true, been deduced from the delta of the Mississippi and the gorge of Niagara; but the deposits of the former have been found by Hilgard to be in great part marine, and the excavation of the latter began at a period probably long anterior to the advent of man.

But another question remains. From the similarities existing in the animals and plants of regions in the southern hemisphere now widely separated by the ocean, it has been inferred that Post-pliocene land of great extent existed there; and that on this land men may have lived before the continents of the northern hemisphere were ready for them. It has even been supposed that, inasmuch as the flora and fauna of Australia have an aspect like that of the Eocene Tertiary, and very low forms of man exist in that part of the world, these low races are the oldest of all, and may date from Tertiary times. Positive evidence of this, however, there is none. These races have no monuments; nor, so far as known, have they left their remains in Post-pliocene deposits. It depends on the assumptions that the ruder races of men are the oldest; and that man has no greater migratory powers than other animals. The first is probably false, as being contrary to history; and also to the testimony of palæontology with reference to the laws of creation. The second is certainly false; for we know that man has managed

to associate himself with every existing fauna and flora, even in modern times; and that the most modern races have pitched their tents amid tree-ferns and Proteaceæ, and have hunted kangaroos and emus. Further, when we consider that the productions of the southern hemisphere are not only more antique than those of the northern, but, on the whole, less suited for the comfortable subsistence of man and the animals most useful to him; and that the Post-pliocene animals of the southern hemisphere were of similar types with their modern successors, we are the less inclined to believe that these regions would be selected as the cradle of the human race.

CONDENSED TABULAR VIEW OF THE AGES AND PERIODS OF THE NEOZOIC.

TIME.	AGES.	PERIODS.	ANIMALS AND PLANTS.
NEOZOIC OR CAINOZOIC.	<p>MODERN ... {}</p>	<p>Newer. Still future (?) Middle. Historic. Older. Pre-historic.</p>	<p>Age of Man. Ages of Mammals.</p>
	<p>Post-PLIOCENE ... {}</p>	<p>N. Post-glacial gravels and cave deposits. Saxe-cava sand and terraces (America). M. Marine clays. Leta clay, Erie clay (America). O. Glacial Drift. Boulder clay (America).</p>	<p>Recent species of Aquatic Invertebrates. Teleostian Fishes and Squaloid sharks prevail.</p>
	<p>PLIOCENE ... {}</p>	<p>N. Norwich crag; Sicilian and Val d'Arno beds. M. Sumter group (America). O. Red and Coralline crag; Sub-apennine beds.</p>	<p>Ages of Angiosperms and Palms.</p>
	<p>MIOCENE ... {}</p>	<p>N. Faluns of Lorraine; Upper Molasse; Siwalk beds; Einingen plant beds. York-town beds (America). M. Upper Paris beds; Hempstead and Bovey beds; Lower Molasse. Nebraska beds (West America). O. Gypseous series, Paris. Vicksburg group (America). M. Calcaire Grossier, Bagshot and Alum Bay beds. Jackson group (America). O. Argile Plastique; London clay. Claiborne group (America).</p>	<p>“And God said—let the land bring forth herbivorous beasts and carnivorous beasts, after their kinds; and it was so.” “And God created man, in His own image.”</p>

CHAPTER XIII.

CLOSE OF THE POST-PLIOCENE, AND ADVENT OF MAN.

(Continued.)

TURNING from these difficult questions of time, we may now look at the assemblage of land-animals presented by the Post-glacial period. Here, for the first time in the great series of continental elevations and depressions, we find the newly-emerging land peopled with familiar forms. Nearly all the modern European animals have left their bones in the clays, gravels, and cavern deposits which belong to this period; but with them are others either not now found within the limits of temperate Europe, or altogether extinct. Thus the remarkable fact comes out, that the uprising land was peopled at first with a more abundant fauna than that which it now sustains, and that many species, and among these some of the largest and most powerful, have been weeded out, either before the advent of man or in the changes which immediately succeeded that event. That in the Post-glacial period so many noble animal species should have been overthrown in the struggle for existence, without leaving any successors, at least in Europe, is one of the most remarkable phenomena in the history of life on our planet.

According to Pictet,* the Post-glacial beds of Europe afford ninety-eight species of mammals, of which fifty-seven still live there, the remainder being either locally or wholly extinct. According to Mr. Boyd Dawkins,† in Great Britain about twelve Pliocene species survived the Glacial period, and reappeared in the British Islands in the Post-glacial. To these were added forty-one species—making in all fifty-three, whose remains are found in the gravels and caves of the latter period. Of these, in the Modern period twenty-eight, or rather more than one-half, survive, fourteen are wholly extinct, and eleven are locally extinct.

Among the extinct beasts, were some of very remarkable character. There were two or more species of elephant, which seem in this age to have overspread, in vast herds, all the plains of Northern Europe and Asia; and one of which we know, from the perfect specimen found embedded in the frozen soil of Siberia, lived till a very modern period; and was clothed with long hair and fur, fitting it for a cold climate. There were also three or four species of rhinoceros, one of which at least (the *R. Tichorhinus*) was clad with wool like the great Siberian mammoth. With these was a huge hippopotamus (*H. major*), whose head-quarters would, however, seem to have been farther south than England, or

* Palæontologie.

† "Journal of Geological Society," and Palæontographical Society's publications.



BRITAIN IN THE POST-PLIOCENE AGE.

Musk-sheep, Hippopotamus, Machairodus, Mammoth, Woolly Rhinoceros, Long-fronted Ox, and Irish Stag. The animals are taken from Mr. Waterhouse Hawkins's picture, "Struggles of Life among British Animals of the Antediluvian Times," London: 1850. The landscape is that of the later part of the cold Post-pliocene period.

which perhaps inhabited chiefly the swamps along the large rivers running through areas now under the sea. The occurrence of such an animal shows an abundant vegetation, and a climate so mild, that the rivers were not covered with heavy ice in winter; for the supposition that this old hippopotamus was a migratory animal seems very unlikely. Another animal of this time, was the magnificent deer, known as the Irish elk; and which perhaps had its principal abode on the great plain which is now the Irish Sea. The terrible machairodus, or cymetar-toothed tiger, was continued from the Pliocene; and in addition to species of bear still living, there was a species of gigantic size, probably now extinct, the cave bear. Evidences are accumulating, to show that all or nearly all these survived until the human period.

If we turn now to those animals which are only locally extinct, we meet with some strange, and at first sight puzzling anomalies. Some of these are creatures now limited to climates much colder than that of Britain. Others now belong to warmer climates. Conspicuous among the former are the musk-sheep, the elk, the reindeer, the glutton, and the lemming. Among the latter, we see the panther, the lion, and the Cape hyena. That animals now so widely separated as the musk-sheep of Arctic America and the hyena of South Africa, could ever have inhabited the same forests, seems a dream of the wildest fancy. Yet it is not difficult to find a probable solution of the mystery. In North America, at the pre-

sent day, the puma, or American lion, comes up to the same latitudes with the caribou, or reindeer, and moose; and in Asia, the tiger extends its migrations into the abodes of boreal animals in the plains of Siberia. Even in Europe, within the historic period, the reindeer inhabited the forests of Germany; and the lion extended its range nearly as far northward. The explanation lies in the co-existence of a densely wooded country with a temperate climate; the forests affording to southern animals shelter from the cold of winter; and equally to the northern animals protection from the heat of summer. Hence our wonder at this association of animals of diverse habitudes as to climate, is merely a prejudice arising from the present exceptional condition of Europe. Still it is possible that changes unfavourable to some of these animals, were in progress before the arrival of man, with his clearings and forest fires and other disturbing agencies. Even in America, the megalonyx, or gigantic sloth, the mammoth, the mastodon, the fossil horse, and many other creatures, disappeared before the Modern period; and on both continents the great Post-glacial subsidence or deluge may have swept away some of the species. Such a supposition seems necessary to account for the phenomena of the gravel and cave deposits of England, and Cope has recently suggested it in explanation of similar storehouses of fossil animals in America.*

* Proceedings of the American Philosophical Society, April, 1871.

Among the many pictures which this fertile subject calls up, perhaps none is more curious than that presented by the Post-glacial cavern deposits. We may close our survey of this period with the exploration of one of these strange repositories; and may select Kent's Hole at Torquay, so carefully excavated and illumined with the magnesium light of scientific inquiry by Mr. Pengelly and a committee of the British Association.

The somewhat extensive and ramifying cavern of Kent's Hole is an irregular excavation, evidently due partly to fissures in limestone rock, and partly to the erosive action of water enlarging such fissures into chambers and galleries. At what time it was originally cut we do not know, but it must have existed as a cavern at the close of the Pliocene or beginning of the Post-pliocene period, since which time it has been receiving a series of deposits which have quite filled up some of its smaller branches.

First and lowest, according to Mr. Pengelly, is a "breccia," or mass of broken and rounded stones, with hardened red clay filling the interstices. Most of the stones are of the rock which forms the roof and walls of the cave, but many, especially the rounded ones, are from more distant parts of the surrounding country. In this mass, the depth of which is unknown, are numerous bones, all of one kind of animal, the cave bear, a creature which seems to have lived in Western Europe from the close of the Pliocene down to the modern period. It must have been one of the

earliest and most permanent tenants of Kent's Hole at a time when its lower chambers were still filled with water. Next above the breccia is a floor of "stalagmite," or stony carbonate of lime, deposited from the drippings of the roof, and in some places three feet thick. This also contains bones of the cave bear, deposited when there was less access of water to the cavern. Mr. Pengelly infers the existence of man at this time from a single flint flake and a single flint chip found in these beds; but mere flakes and chips of flint are too often natural to warrant such a conclusion.

After the old stalagmite floor above mentioned was formed, the cave again received deposits of muddy water and stones; but now a change occurs in the remains embedded. This stony clay, or "cave earth," has yielded an immense quantity of teeth and bones, including those of the elephant, rhinoceros, horse, hyena, cave bear, reindeer, and Irish elk. With these were found weapons of chipped flint, and harpoons, needles, and bodkins of bone, precisely similar to those of the North American Indians and other rude races. The "cave earth" is four feet or more in thickness. It is not stratified, and contains many fallen fragments of rock, rounded stones, and broken pieces of stalagmite. It also has patches of the excrement of hyenas, which the explorers suppose to indicate the temporary residence of these animals; and in one spot, near the top, is a limited layer of burnt wood, with remains which indicate the cooking and eating of repasts of animal food by man. It is clear that when this bed was formed

the cavern was liable to be inundated with muddy water, carrying stones and other heavy objects, and breaking up in places the old stalagmite floor. One of the most puzzling features, especially to those who take an exclusively uniformitarian view, is, that the entrance of water-borne mud and stones implies a level of the bottom of the water in the neighbouring valleys of about 100 feet above its present height. The cave earth is covered by a second crust of stalagmite, less dense and thick than that below, and containing only a few bones, which are of the same general character with those below, but include a fragment of a human jaw with teeth. Evidently, when this stalagmite was formed, the influx of water-borne materials had ceased, or nearly so; but whether the animals previously occupying the country still continued in it, or only accidental bones, etc., were introduced into the cave or lifted from the bed below, does not appear.

The next bed marks a new change. It is a layer of black mould from three to ten inches thick. Its microscopic structure does not seem to have been examined; but it is probably a forest soil, introduced by growth, by water, by wind, and by ingress of animals, at a time when the cave was nearly in its present state, and the surrounding country densely wooded. This bed contains bones of animals, all of them modern, and works of art ranging from the old British times before the Roman invasion up to the porter-bottles and dropped halfpence of modern visi-

tors. Lastly, in and upon the black mould are many fallen blocks from the roof of the cave.

There can be no doubt that this cave and the neighbouring one of Brixham have done very much to impress the minds of British geologists with ideas of the great antiquity of man, and they have, more than any other Post-glacial monuments, shown the persistence of some animals now extinct up to the human age. Of precise data for determining time, they have, however, given nothing. The only measures which seem to have been applied, namely, the rate of growth of stalagmite and the rate of erosion of the neighbouring valleys, are, from the very sequence of the deposits, obviously worthless; and the only apparently available constant measure, namely, the fall of blocks from the roof, seems not yet to have been applied. We are therefore quite uncertain as to the number of centuries involved in the filling of this cave, and must remain so until a surer system of calculation is adopted. We may, however, attempt to sketch the series of events which it indicates.

The animals found in Kent's Hole are all "Post-glacial." They therefore inhabited the country after it rose from the great Glacial submergence. Perhaps the first colonists of the coasts of Devonshire in this period were the cave bears, migrating on floating ice, and subsisting, like the Arctic bear, and the black bears of Anticosti, on fish, and on the garbage cast up by the sea. They found Kent's Hole a sea-side cavern, with perhaps some of its galleries still full of

water, and filling with breccia, with which the bones of dead bears became mixed. As the land rose, these creatures for the most part betook themselves to lower levels, and in process of time the cavern stood upon a hill-side, perhaps several hundreds of feet above the sea; and the mountain torrents, their beds not yet emptied of glacial detritus, washed into it stones and mud and carcases of animals of many species which had now swarmed across the plains elevated out of the sea, and multiplied in the land. This was the time of the cave earth; and before its deposit was completed, though how long before, a confused and often-disturbed bed of this kind cannot tell, man himself seems to have been added to the inhabitants of the British land. In pursuit of game he sometimes ascended the valleys beyond the cavern, or even penetrated into its outer chambers; or perhaps there were even in those days rude and savage hill-men, inhabiting the forests and warring with the more cultivated denizens of plains below, which are now deep under the waters. Their weapons, lost in hunting, or buried in the flesh of wounded animals which crept to the streams to assuage their thirst, are those found in the cave earth. The absence of human bones may merely show that the mighty hunters of those days were too hardy, athletic, and intelligent, often to perish from accidental causes, and that they did not use this cavern for a place of burial. But the land again subsided. The valley of that now nameless river, of which the Rhine, the Thames, and the Severn may have alike been tribu-

taries, disappeared under the sea; and some tribe, driven from the lower lands, took refuge in this cave, now again near the encroaching waves, and left there the remains of their last repasts ere they were driven farther inland or engulfed in the waters. For a time the cavern may have been wholly submerged, and the charcoal of the extinguished fires became covered with its thin coating of clay. But ere long it re-emerged to form part of an island, long barren and desolate; and the valleys having been cut deeper by the receding waters, it no longer received muddy deposits, and the crust formed by drippings from its roof contained only bones and pebbles washed by rains or occasional land floods from its own clay deposits. Finally, the modern forests overspread the land, and were tenanted by the modern animals. Man returned to use the cavern again as a place of refuge or habitation, and to leave there the relics contained in the black earth. This seems at present the only intelligible history of this curious cave and others resembling it; though, when we consider the imperfection of the results obtained even by a large amount of labour, and the difficult and confused character of the deposits in this and similar caves, too much value should not be attached to such histories, which may at any time be contradicted or modified by new facts or different explanations of those already known. The time involved depends very much, as already stated, on the question whether we regard the Post-glacial subsidence and re-elevation as somewhat sudden, or as

occupying long ages at the slow rate at which some parts of our continents are now rising or sinking.*

Such are the glimpses, obscure though stimulating to the imagination, which geology can give of the circumstances attending the appearance of man in Western Europe. How far we are from being able to account for his origin, or to give its circumstances and relative dates for the whole world, the reader will readily understand. Still it is something to know that there is an intelligible meeting-place of the later geological ages and the age of man, and that it is one inviting to many and hopeful researches. It is curious also to find that the few monuments disinterred by geology, the antediluvian record of Holy Scripture, and the golden age of heathen tradition, seem alike to point to similar physical conditions, and to that simple state of the arts of life in which "gold and wampum and flint stones"† constituted the chief material treasures of the earliest tribes of men. They also point to the immeasurable elevation, then as now, of man over his brute rivals for the dominion of the earth. To the naturalist this subject opens up most inviting yet most difficult paths of research, to be

* Another element in this is also the question raised by Dawkins, Geikie, and others as to subdivisions of the Post-glacial period and intermissions of the Glacial cold. After careful consideration of these views, however, I cannot consider them as of much importance.

† So I read the "gold, bedolah, and shoham" of the description of Eden in Genesis ii.—the oldest literary record of the stone age.

entered on with caution and reverence, rather than in the bold and dashing spirit of many modern attempts. The Christian, on his part, may feel satisfied that the scattered monumental relics of the caves and gravels will tell no story very different from that which he has long believed on other evidence, nor anything inconsistent with those views of man's heavenly origin and destiny which have been the most precious inheritance of the greatest and best minds of every age, from that early pre-historic period when men, "palæolithic" men, no doubt, began to "invoke the name of Jehovah," the coming Saviour, down to those times when life and immortality are brought to light, for all who will see, by the Saviour already come.

In completing this series of pictures, I wish emphatically to insist on the imperfection of the sketches which I have been able to present, and which are less, in comparison with the grand march of the creative work, even as now imperfectly known to science, than the roughest pencilling of a child when compared with a finished picture. If they have any popular value, it will be in presenting such a broad general view of a great subject as may induce further study to fill up the details. If they have any scientific value, it will be in removing the minds of British students for a little from the too exclusive study of their own limited marginal area, which has been to them too much the "celestial empire" around which all other countries must be arranged, and in divesting the subject of the special colour-

ing given to it by certain prominent cliques and parties.

Geology as a science is at present in a peculiar and somewhat exceptional state. Under the influence of a few men of commanding genius belonging to the generation now passing away, it has made so gigantic conquests that its armies have broken up into bands of specialists, little better than scientific banditti, liable to be beaten in detail, and prone to commit outrages on common sense and good taste, which bring their otherwise good cause into disrepute. The leaders of these bands are, many of them, good soldiers, but few of them fitted to be general officers, and none of them able to reunite our scattered detachments. We need larger minds, of broader culture and wider sympathies, to organise and rule the lands which we have subdued, and to lead on to further conquests.

In the present state of natural science in Britain, this evil is perhaps to be remedied only by providing a wider and deeper culture for our young men. Few of our present workers have enjoyed that thorough training in mental as well as physical science, which is necessary to enable men even of great powers to take large and lofty views of the scheme of nature. Hence we often find men who are fair workers in limited departments, reasoning most illogically, taking narrow and local views, elevating the exception into the rule, led away by baseless metaphysical subtleties, quarrelling with men who look at their specialties

from a different point of view, and even striving and plotting for the advancement of their own hobbies. Such defects certainly mar much of the scientific work now being done. In the more advanced walks of scientific research, they are to some extent neutralised by that free discussion which true science always fosters; though even here they sometimes vexatiously arrest the progress of truth, or open floodgates of error which it may require much labour to close. But in public lectures and popular publications they run riot, and are stimulated by the mistaken opposition of narrow-minded good men, by the love of the new and sensational, and by the rivalry of men struggling for place and position. To launch a clever and startling fallacy which will float for a week and stir up a hard fight, seems almost as great a triumph as the discovery of an important fact or law; and the honest student is distracted with the multitude of doctrines, and hustled aside by the crowd of ambitious groundlings.

The only remedy in the case is a higher and more general scientific education; and yet I do not wonder that many good men object to this, simply because of the difficulty of finding honest and competent teachers, themselves well grounded in their subjects, and free from that too common insanity of specialists and half-educated men, which impels them to run amuck at everything that does not depend on their own methods of research. This is a difficulty which can be met in our time only by the general good

sense and right feeling of the community taking a firm hold of the matter, and insisting on the organization and extension of the higher scientific education, as well as that of a more elementary character, under the management of able and sane men. Yet even if not so counteracted, present follies will pass away, and a new and better state of natural science will arise in the future, by its own internal development. Science cannot long successfully isolate itself from God. Its life lies in the fact that it is the exponent of the plans and works of the great Creative Will. It must, in spite of itself, serve His purposes, by dispelling blighting ignorance and superstition, by lighting the way to successive triumphs of human skill over the powers of nature, and by guarding men from the evils that flow from infringement of natural laws. And it cannot fail, as it approaches nearer to the boundaries of that which may be known by finite minds, to be humbled by the contemplation of the infinite, and to recognise therein that intelligence of which the human mind is but the image and shadow.

It may be that theologians also are needed who shall be fit to take the place of Moses to our generation, in teaching it again the very elements of natural theology; but let them not look upon science as a cold and godless demon, holding forth to the world a poisoned cup cunningly compounded of truth and falsehood; but rather as the natural ally and associate of the gospel of salvation. The matter is so put in one of those visions which close the canon of

revelation, when the prophet sees a mighty angel having the "everlasting gospel to preach;" but he begins his proclamation by calling on men to "worship Him *that made heaven and earth and the sea and the fountains of waters.*" Men must know God as the Creator even before they seek Him as a benefactor and redeemer. Thus religion must go hand in hand with all true and honest science. In this way only may we look forward to a time when a more exact and large-minded science shall be in perfect accord with a more pure and spiritual Christianity, when the natural and the spiritual shall be seen to be the necessary complements of each other, and when we shall hear no more of reconciliations between science and theology, because there will be no quarrels to reconcile. Already, even in the present chaos of scientific and religious opinion, indications can be seen by the observant, that the Divine Spirit of order is breathing on the mass, and will evolve from it new and beautiful worlds of mental and spiritual existence.

CHAPTER XIV.

PRIMITIVE MAN. CONSIDERED WITH REFERENCE TO MODERN THEORIES AS TO HIS ORIGIN.

THE geological record, as we have been reading it, introduces us to primitive man, but gives us no distinct information as to his origin. Tradition and revelation have, it is true, their solutions of the mystery, but there are, and always have been, many who will not take these on trust, but must grope for themselves with the taper of science or philosophy into the dark caverns whence issue the springs of humanity. In former times it was philosophic speculation alone which lent its dim and uncertain light to these bold inquirers; but in our day the new and startling discoveries in physics, chemistry, and biology have flashed up with an unexpected brilliancy, and have at least served to dazzle the eyes and encourage the hopes of the curious, and to lead to explorations more bold and systematic than any previously undertaken. Thus has been born amongst us, or rather renewed, for it is a very old thing, that evolutionist philosophy, which has been well characterised as the "baldest of all the philosophies which have sprung up in our world," and which solves the question of human origin by the assumption that human nature exists potentially in mere inorganic matter, and that a chain

of spontaneous derivation connects incandescent molecules or star-dust with the world, and with man himself.

This evolutionist doctrine is itself one of the strangest phenomena of humanity. It existed, and most naturally, in the oldest philosophy and poetry, in connection with the crudest and most uncritical attempts of the human mind to grasp the system of nature; but that in our day a system destitute of any shadow of proof, and supported merely by vague analogies and figures of speech, and by the arbitrary and artificial coherence of its own parts, should be accepted as a philosophy, and should find able adherents to string upon its thread of hypotheses our vast and weighty stores of knowledge, is surpassingly strange. It seems to indicate that the accumulated facts of our age have gone altogether beyond its capacity for generalisation; and but for the vigour which one sees everywhere, it might be taken as an indication that the human mind has fallen into a state of senility, and in its dotage mistakes for science the imaginations which were the dreams of its youth.

In many respects these speculations are important and worthy of the attention of thinking men. They seek to revolutionise the religious beliefs of the world, and if accepted would destroy most of the existing theology and philosophy. They indicate tendencies among scientific thinkers, which, though probably temporary, must, before they disappear, descend to lower strata, and reproduce themselves in grosser

forms, and with most serious effects on the whole structure of society. With one class of minds they constitute a sort of religion, which so far satisfies the craving for truths higher than those which relate to immediate wants and pleasures. With another and perhaps larger class, they are accepted as affording a welcome deliverance from all scruples of conscience and fears of a hereafter. In the domain of science evolutionism has like tendencies. It reduces the position of man, who becomes a descendant of inferior animals, and a mere term in a series whose end is unknown. It removes from the study of nature the ideas of final cause and purpose; and the evolutionist, instead of regarding the world as a work of consummate plan, skill, and adjustment, approaches nature as he would a chaos of fallen rocks, which may present forms of castles and grotesque profiles of men and animals, but they are all fortuitous and without significance. It obliterates the fine perception of differences from the mind of the naturalist, and resolves all the complicated relations of living things into some simple idea of descent with modification. It thus destroys the possibility of a philosophical classification, reducing all things to a mere series, and leads to a rapid decay in systematic zoology and botany, which is already very manifest among the disciples of Spencer and Darwin in England. The effect of this will be, if it proceeds further, in a great degree to destroy the educational value and popular interest attaching to these sciences, and to throw them

down at the feet of a system of debased metaphysics. As redeeming features in all this, are the careful study of varietal forms, and the inquiries as to the limits of species, which have sprung from these discussions, and the harvest of which will be reaped by the true naturalists of the future.

Thus these theories as to the origin of men and animals and plants are full of present significance, and may be studied with profit by all; and in no part of their applications more usefully than in that which relates to man. Let us then inquire,—1. What is implied in the idea of evolution as applied to man? 2. What is implied in the idea of creation? 3. How these several views accord with what we actually know as the result of scientific investigation? The first and second of these questions may well occupy the whole of this chapter, and we shall be able merely to glance at their leading aspects. In doing so, it may be well first to place before us in general terms the several alternatives which evolutionists offer, as to the mode in which the honour of an origin from apes or ape-like animals can be granted to us, along with the opposite view as to the independent origin of man which have been maintained either on scientific or scriptural grounds.

All the evolutionist theories of the origin of man depend primarily on the possibility of his having been produced from some of the animals more closely allied to him, by the causes now in operation which lead to varietal forms, or by similar causes which have

been in operation; and some attach more and others less weight to certain of these causes, or gratuitously suppose others not actually known. Of such causes of change some are internal and others external to the organism. With respect to the former, one school assumes an innate tendency in every species to change in the course of time.* Another believes in exceptional births, either in the course of ordinary generation or by the mode of parthenogenesis.† Another refers to the known facts of reproductive acceleration or retardation observed in some humble creatures.‡ New forms arising in any of these ways or fortuitously, may, it is supposed, be perpetuated and increased and further improved by favouring external circumstances and the effort of the organism to avail itself of these,§ or by the struggle for existence and the survival of the fittest. ||

On the other hand, those who believe in the independent origin of man admit the above causes as adequate only to produce mere varieties, liable to return into the original stock. They may either hold that man has appeared as a product of special and miraculous creation, or that he has been created mediately by the operation of forces also concerned in the production of other animals, but the precise nature of which is still unknown to us; or lastly, they may hold what seems to be the view favoured by the book of Genesis, that his bodily form is a product

* Parsons, Owen.

† Mivart, Ferris.

‡ Hyatt and Cope.

§ Lamarck, etc.

|| Darwin, etc.

of mediate creation and his spiritual nature a direct emanation from his Creator.

The discussion of all these rival theories would occupy volumes, and to follow them into details would require investigations which have already bewildered many minds of some scientific culture. Further, it is the belief of the writer that this plunging into multitudes of details has been fruitful of error, and that it will be a better course to endeavour to reach the root of the matter by looking at the foundations of the general doctrine of evolution itself, and then contrasting it with its rival.

Taking, then, this broad view of the subject, two great leading alternatives are presented to us. Either man is an independent product of the will of a Higher Intelligence, acting directly or through the laws and materials of his own institution and production, or he has been produced by an unconscious evolution from lower things. It is true that many evolutionists, either unwilling to offend, or not perceiving the logical consequences of their own hypothesis, endeavour to steer a middle course, and to maintain that the Creator has proceeded by way of evolution. But the bare, hard logic of Spencer, the greatest English authority on evolution, leaves no place for this compromise, and shows that the theory, carried out to its legitimate consequences, excludes the knowledge of a Creator and the possibility of His work. We have, therefore, to choose between evolution and creation; bearing in mind, however, that there may be a place

in nature for evolution, properly limited, as well as for other things, and that the idea of creation by no means excludes law and second causes.

Limiting ourselves in the first place to theories of evolution, and to these as explaining the origin of species of living beings, and especially of man, we naturally first inquire as to the basis on which they are founded. Now no one pretends that they rest on facts actually observed, for no one has ever observed the production of even one species. Nor do they even rest, like the deductions of theoretical geology, on the extension into past time of causes of change now seen to be in action. Their probability depends entirely on their capacity to account hypothetically for certain relations of living creatures to each other, and to the world without; and the strongest point of the arguments of their advocates is the accumulation of cases of such relations supposed to be accounted for. Such being the kind of argument with which we have to deal, we may first inquire what we are required to believe as conditions of the action of evolution, and secondly, to what extent it actually does explain the phenomena.

In the first place, as evolutionists, we are required to assume certain forces, or materials, or both, with which evolution shall begin. Darwin, in his *Origin of Species*, went so far as to assume the existence of a few of the simpler types of animals; but this view, of course, was only a temporary resting-place for his theory. Others assume a primitive protoplasm, or

physical basis of life, and arbitrarily assigning to this substance properties now divided between organised and unorganised, and between dead and living matter, find no difficulty in deducing all plants and animals from it. Still, even this cannot have been the ultimate material. It must have been evolved from something. We are thus brought back to certain molecules of star-dust, or certain conflicting forces, which must have had self-existence, and must have potentially included all subsequent creatures. Otherwise, if with Spencer we hold that God is "unknowable," and creation "unthinkable," we are left suspended on nothing over a bottomless void, and must adopt as the initial proposition of our philosophy, that all things were made out of nothing, and by nothing; unless we prefer to doubt whether anything exists, and to push the doctrine of relativity to the unscientific extreme of believing that we can study the relations of things non-existent or unknown. So we must allow the evolutionist some small capital to start with; observing, however, that self-existent matter in a state of endless evolution is something of which we cannot possibly have any definite conception.

Being granted thus much, the evolutionist next proceeds to demand that we shall also believe in the indefinite variability of material things, and shall set aside all idea that there is any difference in kind between the different substances which we know. They must all be mutually convertible, or at least

derivable from some primitive material. It is true that this is contrary to experience. The chemist holds that matter is of different kinds, that one element cannot be converted into another; and he would probably smile if told that, even in the lapse of enormous periods of time, limestone could be evolved out of silica. He may think that this is very different from the idea that a snail can be evolved from an oyster, or a bird from a reptile. But the zoologist will inform him that species of animals are only variable within certain limits, and are not transmutable, in so far as experience and experiment are concerned. They have their allotropic forms, but cannot be changed into one another.

But if we grant this second demand, the evolutionist has a third in store for us. We must also admit that by some inevitable necessity the changes of things must in the main take place in one direction, from the more simple to the more complex, from the lower to the higher. At first sight this seems not only to follow from the previous assumptions, but to accord with observation. Do not all living things rise from a simpler to a more complex state? has not the history of the earth displayed a gradually increasing elevation and complexity? But, on the other hand, the complex organism becoming mature, resolves itself again into the simple germ, and finally is dissolved into its constituent elements. The complex returns into the simple, and what we see is not an evolution, but a revolution. In like manner, in

geological time, the tendency seems to be ever to disintegration and decay. This we see everywhere, and find that elevation occurs only by the introduction of new species in a way which is not obvious, and which may rather imply the intervention of a cause from without; so that here also we are required to admit as a general principle what is contrary to experience.

If, however, we grant the evolutionist these postulates, we must next allow him to take the facts of botany and zoology out of their ordinary connection, and thread them like a string of beads, as Herbert Spencer has done in his "Biology," on the threefold cord thus fashioned. This done, we next find, as might have been expected, certain gaps or breaks which require to be cunningly filled with artificial material, in order to give an appearance of continuity to the whole.

The first of these gaps which we notice is that between dead and living matter. It is easy to fill this with such a term as protoplasm, which includes matter both dead and living, and so to ignore this distinction; but practically we do not yet know as a possible thing the elevation of matter, without the agency of a previous living organism, from that plane in which it is subject merely to physical force, and is unorganised, to that where it becomes organised, and lives. Under that strange hypothesis of the origin of life from meteors, with which Sir William Thomson closed his address at a late meeting of the British

Association, there was concealed a cutting sarcasm which the evolutionists felt. It reminded them that the men who evolve all things from physical forces do not yet know how these forces can produce the phenomena of life even in its humblest forms. It is true that the scientific world has been again and again startled by the announcement of the production of some of the lowest forms of life, either from dead organic matter, or from merely mineral substances; but in every case heretofore the effort has proved as vain as the analogies attempted to be set up between the formation of crystals and that of organized tissues are fallacious.

A second gap is that which separates vegetable and animal life. These are necessarily the converse of each other, the one deoxidizes and accumulates, the other oxidizes and expends. Only in reproduction or decay does the plant simulate the action of the animal, and the animal never in its simplest forms assumes the functions of the plant. Those obscure cases in the humbler spheres of animal and vegetable life which have been supposed to show a union of the two kingdoms, disappear on investigation. This gap can, I believe, be filled up only by an appeal to our ignorance. There may be, or may have been, some simple creature unknown to us, on the extreme verge of the plant kingdom, that was capable of passing the limit and becoming an animal. But no proof of this exists. It is true that the primitive germs of many kinds of humble plants and animals

are so much alike, that much confusion has arisen in tracing their development. It is also true that some of these creatures can subsist under very dissimilar conditions, and in very diverse states, and that under the specious name of Biology,* we sometimes find a mass of these confusions, inaccurate observations and varietal differences made to do duty for scientific facts. But all this does not invalidate the grand primary distinction between the animal and the plant, which should be thoroughly taught and illustrated to all young naturalists, as one of the best antidotes to the fallacies of the evolutionist school.

A third is that between any species of animal or plant and any other species. It was this gap, and this only, which Darwin undertook to fill up by his great work on the origin of species, but, notwithstanding the immense amount of material thus expended, it yawns as wide as ever, since it must be

* It is doubtful whether men who deny the existence of vital force have a right to call their science "Biology;" any more than atheists have to call their doctrine "Theology;" and it is certain that the assumption of a science of Biology as distinct from Phytology and Zoology, or including both, is of the nature of a "pious fraud" on the part of the more enlightened evolutionists. The objections stated in the text, to what have been called Archebiosis and Heterogenesis seem perfectly applicable, in so far as I can judge from a friendly review by Wallace, to the mass of heterogeneous material accumulated by Dr. Bastian in his recent volumes. The conclusions of this writer, would also, if established, involve evolution in a fatal *embarras des richesses*, by the hourly production during all geological time, of millions of new forms all capable of indefinite development.

admitted that no case has been ascertained in which an individual of one species has transgressed the limits between it and other species. However extensive the varieties produced by artificial breeding, the essential characters of the species remain, and even its minor characters may be reproduced, while the barriers established in nature between species by the laws of their reproduction, seem to be absolute.

With regard to species, however, it must be observed that naturalists are not agreed as to what constitutes a species. Many so-called species are probably races or varieties, and one benefit of these inquiries has been to direct attention to the proper discrimination of species from varieties among animals and plants. The loose discrimination of species, and the tendency to multiply names, have done much to promote evolutionist views; but the researches of the evolutionists themselves have shown that we must abandon transmutation of true species as a thing of the present; and if we imagine it to have occurred, must refer it to the past.

Another gap is that between the nature of the animal and the self-conscious, reasoning, moral nature of man. We not only have no proof that any animal can, by any force in itself, or by any merely physical influences from without, rise to such a condition; but the thing is in the highest degree improbable. It is easy to affirm, with the grosser materialists, that thought is a secretion of brain, as bile is of the liver; but a moment's thought shows that no real

analogy obtains between the cases. We may vaguely suppose, with Darwin, that the continual exercise of such powers as animals possess, may have developed those of man. But our experience of animals shows that their intelligence differs essentially from that of man, being a closed circle ever returning into itself, while that of man is progressive, inventive, and accumulative, and can no more be correlated with that of the animal than the vital phenomena of the animal with those of the plant. Nor can the gap between the higher religious and moral sentiments of man, and the instinctive affections of the brutes, be filled up with that miserable ape imagined by Lubbock, which, crossed in love, or pining with cold and hunger, conceived, for the first time in its poor addled pate, "the dread of evil to come," and so became the father of theology. This conception, which Darwin gravely adopts, would be most ludicrous, but for the frightful picture which it gives of the aspect in which religion appears to the mind of the evolutionist.

The reader will now readily perceive that the simplicity and completeness of the evolutionist theory entirely disappear when we consider the unproved assumptions on which it is based, and its failure to connect with each other some of the most important facts in nature: that, in short, it is not in any true sense a philosophy, but merely an arbitrary arrangement of facts in accordance with a number of unproved hypotheses. Such philosophies, "falsely so called,"

have existed ever since man began to reason on nature, and this last of them is one of the weakest and most pernicious of the whole. Let the reader take up either of Darwin's great books, or Spencer's "Biology," and merely ask himself as he reads each paragraph, "What is assumed here and what is proved?" and he will find the whole fabric melt away like a vision. He will find, however, one difference between these writers. Darwin always states facts carefully and accurately, and when he comes to a difficulty tries to meet it fairly. Spencer often exaggerates or extenuates with reference to his facts, and uses the arts of the dialectician where argument fails.

Many naturalists who should know better are puzzled with the great array of facts presented by evolutionists; and while their better judgment causes them to doubt as to the possibility of the structures which they study being produced by such blind and material processes, are forced to admit that there must surely be something in a theory so confidently asserted, supported by so great names, and by such an imposing array of relations which it can explain. They would be relieved from their weak concessions were they to study carefully a few of the instances adduced, and to consider how easy it is by a little ingenuity to group undoubted facts around a false theory. I could wish to present here illustrations of this, which abound in every part of the works I have referred to, but space will not permit. One or two must suffice. The first may be taken from one of

the strong points often dwelt on by Spencer in his "Biology."*

"But the experiences which most clearly illustrate to us the process of general evolution are our experiences of special evolution, repeated in every plant and animal. Each organism exhibits, within a short space of time, a series of changes which, when supposed to occupy a period indefinitely great and to go on in various ways instead of one, may give us a tolerably clear conception of organic evolution in general. In an individual development we have compressed into a comparatively infinitesimal space a series of metamorphoses equally vast with those which the hypothesis of evolution assumes to have taken place during those unmeasurable epochs that the earth's crust tells us of. A tree differs from a seed immeasurably in every respect—in bulk, in structure, in colour, in form, in specific gravity, in chemical composition: differs so greatly that no visible resemblance of any kind can be pointed out between them. Yet is the one changed in the course of a few years into the other; changed so gradually that at no moment can it be said, 'Now the seed ceases to be and the tree exists.' What can be more widely contrasted than a newly-born child and the small gelatinous spherule constituting the human ovum? The infant is so complex in structure that a cyclopædia is needed to describe its constituent parts. The germinal vesicle is so simple

* "Principles of Biology," § 118.

that it may be defined in a line. . . . If a single cell under appropriate conditions becomes a man in the space of a few years, there can surely be no difficulty in understanding how, under appropriate conditions, a cell may in the course of untold millions of years give origin to the human race."

"It is true that many minds are so unfurnished with those experiences of nature, out of which this conception is built, that they find difficulty in forming it. . . . To such the hypothesis that by any series of changes a protozoan should ever give origin to a mammal seems grotesque—as grotesque as did Galileo's assertion of the earth's movement seem to the Aristoteleans; or as grotesque as the assertion of the earth's sphericity seems now to the New Zealanders."

I quote the above as a specimen of evolutionist reasoning from the hand of a master, and as referring to one of the corner-stones of this strange philosophy. I may remark with respect to it, in the first place, that it assumes those "conditions" of evolution to which I have already referred. In the second place, it is full of inaccurate statements of fact, all in a direction tending to favour the hypothesis. For example, a tree does not differ "immeasurably" from a seed, especially if the seed is of the same species of tree, for the principal parts of the tree and its principal chemical constituents already exist and can be detected in the seed, and unless it were so, the development of the tree from the seed could not take

place. Besides, the seed itself is not a thing self-existent or fortuitous. The production of a seed without a previous tree of the same kind is quite as difficult to suppose as the production of a tree] without a previous seed containing its living embryo. In the third place, the whole argument is one of analogy. The germ becomes a mature animal, passing through many intermediate stages, therefore the animal may have descended from some creature which when mature was as simple as the germ. The value of such an analogy depends altogether on the similarity of the "conditions," which, in such a case, are really the efficient causes at work. The germ of a mammal becomes developed by the nourishment supplied from the system of a parent, which itself produced the germ, and into whose likeness the young animal is destined to grow. These are the "appropriate conditions" of its development. But when our author assumes from this other "appropriate conditions," by which an organism, which on the hypothesis is not a germ but a mature animal, shall be developed into the likeness of something different from its parent, he oversteps the bounds of legitimate analogy. Further, the reproduction of the animal, as observed, is a closed series, beginning at the embryo and returning thither again; the evolution attempted to be established is a progressive series going on from one stage to another. A reproductive circle once established obeys certain definite laws, but its origin, or how it can leave its orbit and revolve in some other, we

cannot explain without the introduction of some new efficient cause. The one term of the analogy is a revolution, and the other is an evolution. The revolution within the circle of the reproduction of the species gives no evidence that at some point the body will fly off at a tangent, and does not even inform us whether it is making progress in space. Even if it is so making progress, its orbit of revolution may remain the same. But it may be said the reproduction of the species is not in a circle but in a spiral. Within the limit of experience it is not so, since, however it may undulate, it always returns into itself. But supposing it to be a spiral, it may ascend or descend, or expand and contract; but this does not connect it with other similar spirals, the separate origin of which is to be separately accounted for.

I have quoted the latter part of the passage because it is characteristic of evolutionists to decry the intelligence of those who differ from them. Now it is fair to admit that it requires some intelligence and some knowledge of nature to produce or even to understand such analogies as those of Mr. Spencer and his followers, but it is no less true that a deeper insight into the study of nature may not only enable us to understand these analogies, but to detect their fallacies. I am sorry to say, however, that at present the hypothesis of evolution is giving so strong a colouring to much of popular and even academic teaching, more especially in the easy and flippant conversion of the facts of embryology into instances

of evolution on the plan of the above extract, that the Spencerians may not long have to complain of want of faith and appreciation on the part of the improved apes whom they are kind enough to instruct as to their lowly origin.

The mention of "appropriate conditions" in the above extract reminds me of another fatal objection to evolution which its advocates continually overlook. An animal or plant advancing from maturity to the adult state is in every stage of its progress a complete and symmetrical organism, correlated in all its parts and adapted to surrounding conditions. Suppose it to become modified in any way, to ever so small an extent, the whole of these relations are disturbed. If the modification is internal and spontaneous, there is no guarantee that it will suit the vastly numerous external agencies to which the creature is subjected. If it is produced by agencies from without, there is no guarantee that it will accord with the internal relations of the parts modified. The probabilities are incalculably great against the occurrence of many such disturbances without the breaking up altogether of the nice adjustment of parts and conditions. This is no doubt one reason of the extinction of so many species in geological time, and also of the strong tendency of every species to spring back to its normal condition when in any way artificially caused to vary. It is also connected with the otherwise mysterious law of the constant transmission of all the characters of the parent.

Spencer and Darwin occasionally see this difficulty, though they habitually neglect it in their reasonings. Spencer even tries to turn one part of it to account as follows :—

“Suppose the head of a mammal to become very much more weighty—what must be the indirect results? The muscles of the neck are put to greater exertions; and the vertebræ have to bear additional tensions and pressures caused both by the increased weight of the head and the stronger contraction of muscles that support and move the head.” He goes on to say that the processes of the vertebræ will have augmented strains put upon them, the thoracic region and fore limbs will have to be enlarged, and even the hind limbs may require modification to facilitate locomotion. He concludes : “Any one who compares the outline of the bison with that of its congener, the ox, will clearly see how profoundly a heavier head affects the entire osseous and muscular system.”

We need not stop to mention the usual inaccuracies as to facts in this paragraph, as, for example, the support of the head being attributed to muscles alone, without reference to the strong elastic ligament of the neck. We may first notice the assumption that an animal can acquire a head “very much more weighty” than that which it had before, a very improbable supposition, whether as a monstrous birth or as an effect of external conditions after birth. But suppose this to have occurred, and what is even less likely, that the very much heavier head is an advan-

tage in some way, what guarantee can evolution give us that the number of other modifications required would take place simultaneously with this acquisition? It would be easy to show that this would depend on the concurrence of hundreds of other conditions within and without the animal, all of which must co-operate to produce the desired effect, if indeed they could produce this effect even by their conjoint action, a power which the writer, it will be observed, quietly assumes, as well as the probability of the initial change in the head. Finally, the *naïveté* with which it is assumed that the bison and the ox are examples of such an evolution, would be refreshing in these artificial days, if instances of it did not occur in almost every page of the writings of evolutionists.

It would only weary the reader to follow evolution any further into details, especially as my object in this chapter is to show that generally, and as a theory of nature and of man, it has no good foundation; but we should not leave the subject without noting precisely the derivation of man according to this theory; and for this purpose I may quote Darwin's summary of his conclusions on the subject.*

"Man," says Mr. Darwin, "is descended from a hairy quadruped, furnished with a tail and pointed ears, probably arboreal in its habits, and an inhabitant of the Old World. This creature, if its whole structure had been examined by a naturalist, would have been classed amongst the quadrumana, as surely

* "Descent of Man," part ii., ch. 21.

as would the common, and still more ancient, progenitor of the Old and New World monkeys. The quadrumana and all the higher mammals are probably derived from an ancient marsupial animal; and this, through a long line of diversified forms, either from some reptile-like or some amphibian-like creature, and this again from some fish-like animal. In the dim obscurity of the past we can see that the early progenitor of all the vertebrata must have been an aquatic animal, provided with branchiæ, with the two sexes united in the same individual, and with the most important organs of the body (such as the brain and heart) imperfectly developed. This animal seems to have been more like the larvæ of our existing marine Ascidiæ than any other form known."

The author of this passage, in condescension to our weakness of faith, takes us no further back than to an Ascidian, or "sea-squirt," the resemblance, however, of which to a vertebrate animal is merely analogical, and, though a very curious case of analogy, altogether temporary and belonging to the young state of the creature, without affecting its adult state or its real affinities with other mollusks. In order, however, to get the Ascidian itself, he must assume all the "conditions" already referred to in the previous part of this article, and fill most of the gaps. He has, however, in the "Origin of Species" and "Descent of Man," attempted merely to fill one of the breaks in the evolutionary series, that between distinct species, leaving us to receive all the rest on mere

faith. Even in respect to the question of species, in all the long chain between the Ascidian and the man, he has not certainly established one link; and in the very last change, that from the ape-like ancestor, he equally fails to satisfy us as to matters so trivial as the loss of the hair, which, on the hypothesis, clothed the pre-human back, and on matters so weighty as the dawn of human reason and conscience.

We thus see that evolution as an hypothesis has no basis in experience or in scientific fact, and that its imagined series of transmutations has breaks which cannot be filled. We have now to consider how it stands with the belief that man has been created by a higher power. Against this supposition the evolutionists try to create a prejudice in two ways. First, they maintain with Herbert Spencer that the hypothesis of creation is inconceivable, or, as they say, "unthinkable;" an assertion which, when examined, proves to mean only that we do not know perfectly the details of such an operation, an objection equally fatal to the origin either of matter or life, on the hypothesis of evolution. Secondly, they always refer to creation as if it must be a special miracle, in the sense of a contravention of or departure from ordinary natural laws; but this is an assumption utterly without proof, since creation may be as much according to law as evolution, though in either case the precise laws involved may be very imperfectly known.

How absurd, they say, to imagine an animal created

at once, fully formed, by a special miracle, instead of supposing it to be slowly elaborated through countless ages of evolution. To Darwin the doctrine of creation is but "a curious illustration of the blindness of preconceived opinion." "These authors," he says, "seem no more startled at a miraculous act of creation than at an ordinary birth; but do they really believe that at innumerable periods in the earth's history, certain elemental atoms have been commanded suddenly to flash into living tissues?" Darwin, with all his philosophic fairness, sometimes becomes almost Spencerian in his looseness of expression; and in the above extract, the terms "miraculous," "innumerable," "elemental atoms," "suddenly," and "flash," all express ideas in no respect necessary to the work of creation. Those who have no faith in evolution as a cause of the production of species, may well ask in return how the evolutionist can prove that creation must be instantaneous, that it must follow no law, that it must produce an animal fully formed, that it must be miraculous. In short, it is a portion of the policy of evolutionists to endeavour to tie down their opponents to a purely gratuitous and ignorant view of creation, and then to attack them in that position.

What, then, is the actual statement of the theory of creation as it may be held by a modern man of science? Simply this; that all things have been produced by the Supreme Creative Will, acting either directly or through the agency of the forces and materials of His own production.

This theory does not necessarily affirm that creation is miraculous, in the sense of being contrary to or subversive of law ; law and order are as applicable to creation as to any other process. It does not contradict the idea of successive creations. There is no necessity that the process should be instantaneous and without progression. It does not imply that all kinds of creation are alike. There may be higher and lower kinds. It does not exclude the idea of similarity or dissimilarity of plan and function as to the products of creation. Distinct products of creation may be either similar to each other in different degrees, or dissimilar. It does not even exclude evolution or derivation to a certain extent : anything once created may, if sufficiently flexible and elastic, be evolved or involved in various ways. Indeed, creation and derivation may, rightly understood, be complementary to each other. Created things, unless absolutely unchangeable, must be more or less modified by influences from within and from without, and derivation or evolution may account for certain subordinate changes of things already made. Man, for example, may be a product of creation, yet his creation may have been in perfect harmony with those laws of procedure which the Creator has set for His own operations. He may have been preceded by other creations of things more or less similar or dissimilar. He may have been created by the same processes with some or all of these, or by different means. His body may have been created in one way, his soul in another. He

may, nay, in all probability would be, part of a plan of which some parts would approach very near to him in structure or functions. After his creation, spontaneous culture and outward circumstances may have moulded him into varieties, and given him many different kinds of speech and of habits. These points are so obvious to common sense that it would be quite unnecessary to insist on them, were they not habitually overlooked or misstated by evolutionists.

The creation hypothesis is also free from some of the difficulties of evolution. It avoids the absurdity of an eternal progression from the less to the more complex. It provides in *will*, the only source of power actually known to us by ordinary experience, an intelligible origin of nature. It does not require us to contradict experience by supposing that there are no differences of kind or essence in things. It does not require us to assume, contrary to experience, an invariable tendency to differentiate and improve. It does not exact the bridging over of all gaps which may be found between the several grades of beings which exist or have existed.

Why, then, are so many men of science disposed to ignore altogether this view of the matter? Mainly, I believe, because, from the training of many of them, they are absolutely ignorant of the subject, and from their habits of thought have come to regard physical force and the laws regulating it as the one power in nature, and to relegate all spiritual powers or forces,

or, as they have been taught to regard them, "supernatural" things, to the domain of the "unknowable." Perhaps some portion of the difficulty may be got over by abandoning altogether the word "supernatural," which has been much misused, and by holding nature to represent the whole cosmos, and to include both the *physical* and the *spiritual*, both of them in the fullest sense subject to law, but each to the law of its own special nature.. I have read somewhere a story of some ignorant orientals who were induced to keep a steam-engine supplied with water by the fiction that it contained a terrible *djin*, or demon, who, if allowed to become thirsty, would break out and destroy them all. Had they been enabled to discard this superstition, and to understand the force of steam, we can readily imagine that they would now suppose they knew the whole truth, and might believe that any one who taught them that the engine was a product of intelligent design, was only taking them back to the old doctrine of the thirsty demon of the boiler. This is, I think, at present, the mental condition of many scientists with reference to creation.

Here we come to the first demand which the doctrine of creation makes on us by way of premises. In order that there may be creation there must be a primary Self-existent Spirit, whose will is supreme. The evolutionist cannot refuse to admit this on as good ground as that on which we hesitate to receive the postulates of his faith. It is no real objection to say that a God can be known to us only partially, and,

with reference to His real essence, not at all; since, even if we admit this, it is no more than can be said of matter and force.

I am not about here to repeat any of the ordinary arguments for the existence of a spiritual First Cause, and Creator of all things, but it may be proper to show that this assumption is not inconsistent with experience, or with the facts and principles of modern science. The statement which I would make on this point shall be in the words of a very old writer, not so well known as he should be to many who talk volubly enough about antagonisms between science and Christianity: "That which is known of God is manifest in them (in men), for God manifested it unto them. For since the creation of the world His invisible things, even His eternal power and divinity are plainly seen, being perceived by means of things that are made."* The statement here is very precise. Certain things relating to God are manifest within men's minds, and are proved by the evidence of His works; these properties of God thus manifested being specially His power or control of all forces, and His divinity or possession of a nature higher than ours. The argument of the writer is that all heathens know this; and, as a matter of fact, I believe it must be admitted even by those most sceptical on such points, that some notion of a divinity has been derived from nature by men of all nations and tribes, if we except, perhaps, a few enlightened positivists of this nineteenth century,

* Paul's Epistle to the Romans, chap. i.

whom excess of light has made blind. "If the light that is in man be darkness, how great is that darkness." But then this notion of a God is a very old and primitive one, and Spencer takes care to inform us that "first thoughts are either wholly out of harmony with things, or in very incomplete harmony with them," and consequently that old beliefs and generally diffused notions are presumably wrong.

Is it true, however, that the modern knowledge of nature tends to rob it of a spiritual First Cause? One can conceive such a tendency, if all our advances in knowledge had tended more and more to identify force with matter in its grosser forms, and to remove more and more from our mental view those powers which are not material; but the very reverse of this is the case. Modern discovery has tended more and more to attach importance to certain universally diffused media which do not seem to be subject to the laws of ordinary matter, and to prove at once the Protean character and indestructibility of forces, the aggregate of which, as acting in the universe, gives us our nearest approach to the conception of physical omnipotence. This is what so many of our evolutionists mean when they indignantly disclaim materialism. They know that there is a boundless energy beyond mere matter, and of which matter seems the sport and toy. Could they conceive of this energy as the expression of a personal will, they would become theists.

Man himself presents a microcosm of matter and force, raised to a higher plane than that of the merely

chemical and physical. In him we find not merely that brain and nerve force which is common to him and lower animals, and which exhibits one of the most marvellous energies in nature, but we have the higher force of will and intellect, enabling him to read the secrets of nature, to seize and combine and utilize its laws like a god, and like a god to attain to the higher discernment of good and evil. Nay, more, this power which resides within man rules with omnipotent energy the material organism, driving its nerve forces until cells and fibres are worn out and destroyed, taxing muscles and tendons till they break, impelling its slave the body even to that which will bring injury and death itself. Surely, what we thus see in man must be the image and likeness of the Great Spirit. We can escape from this conclusion only by one or other of two assumptions, either of which is rather to be called a play upon words than a scientific theory. We may, with a certain class of physicists and physiologists, confine our attention wholly to the fire and the steam, and overlook the engineer. We may assume that with protoplasm and animal electricity, for example, we can dispense with life, and not only with life but with spirit also. Yet he who regards vitality as an unmeaning word, and yet speaks of "living protoplasm," and "dead protoplasm," and affirms that between these two states, so different in their phenomena, no chemical or physical difference exists, is surely either laughing at us, or committing himself to what the Duke of Argyll calls a philosophical bull; and

he who shows us that electrical discharges are concerned in muscular contraction, has just as much proved that there is no need of life or spirit, as the electrician who has explained the mysteries of the telegraph has shown that there can be no need of an operator. Or we may, turning to the opposite extreme, trust to the metaphysical fallacy of those who affirm that neither matter, nor force, nor spirit, need concern them, for that all are merely states of consciousness in ourselves. But what of the conscious self—this self which thinks, and which is in relation with surroundings which it did not create, and which presumably did not create it? and what is the unknown third term which must have been the means of setting up these relations? Here again our blind guides involve us in an absolute self-contradiction.

Thus we are thrown back on the grand old truth that man, heathen and savage, or Christian and scientific, opens his eyes on nature and reads therein both the physical and the spiritual, and in connection with both of these the power and divinity of an Almighty Creator. He may at first have many wrong views both of God and of His works, but as he penetrates further into the laws of matter and mind, he attains more just conceptions of their relations to the Great Centre and Source of all, and instead of being able to dispense with creation, he hopes to be able at length to understand its laws and methods. If unhappily he abandons this high ambition, and contents himself with mere matter and physical force, he

cannot rise to the highest development either of science or philosophy.

It may, however, be said that evolution may admit all this, and still be held as a scientific doctrine in connection with a modified belief in creation. The work of actual creation may have been limited to a few elementary types, and evolution may have done the rest. Evolutionists may still be theists. We have already seen that the doctrine, as carried out to its logical consequences, excludes creation and theism. It may, however, be shown that even in its more modified forms, and when held by men who maintain that they are not atheists, it is practically atheistic, because excluding the idea of plan and design, and resolving all things into the action of unintelligent forces. It is necessary to observe this, because it is the half-way evolutionism which professes to have a Creator somewhere behind it, that is most popular; though it is, if possible, more unphilosophical than that which professes to set out from absolute and eternal nonentity, or from self-existent star-dust containing all the possibilities of the universe.

Absolute atheists recognise in Darwinism, for example, a philosophy which reduces all things to a "gradual summation of innumerable minute and accidental material operations," and in this they are more logical than those who seek to reconcile evolution with design. Huxley, in his "lay sermons," referring to Paley's argument for design founded on the structure of a watch, says that if the watch could be conceived

to be a product of a less perfect structure improved by natural selection, it would then appear to be the "result of a method of trial and error worked by unintelligent agents, as likely as of the direct application of the means appropriate to that end, by an intelligent agent." This is a bold and true assertion of the actual relation of even this modified evolution to rational and practical theism, which requires not merely this God "afar off," who has set the stone of nature rolling and then turned His back upon it, but a present God, whose will is the law of nature, now as in times past. The evolutionist is really in a position of absolute antagonism to the idea of creation, even when held with all due allowance for the variations of created things within certain limits.

Perhaps Paley's old illustration of the watch, as applied by Huxley, may serve to show this as well as any other. If the imperfect watch, useless as a time-keeper, is the work of the contriver, and the perfection of it is the result of unintelligent agents working fortuitously, then it is clear that creation and design have a small and evanescent share in the construction of the fabric of nature. But is it really so? Can we attribute the perfection of the watch to "accidental material operations" any more than the first effort to produce such an instrument? Paley himself long ago met this view of the case, but his argument may be extended by the admissions and pleas of the evolutionists themselves. For example, the watch is altogether a mechanical thing, and this

fact by no means implies that it could not be made by an intelligent and spiritual designer, yet this assumption that physical laws exclude creation and design turns up in almost every page of the evolutionists. Paley has well shown that if the watch contained within itself machinery for making other watches, this would not militate against his argument. It would be so if it could be proved that a piece of metal had spontaneously produced an imperfect watch, and this a more perfect one, and so on; but this is precisely what evolutionists still require to prove with respect both to the watch and to man. On the other hand it is no argument for the evolution of the watch that there may be different kinds of watches, some more and others less perfect, and that ruder forms may have preceded the more perfect. This is perfectly compatible with creation and design. Evolutionists, however, generally fail to make this distinction. Nor would it be any proof of the evolution of the watch to find that, as Spencer would say, it was in perfect harmony with its environment, as, for instance, that it kept time with the revolution of the earth, and contained contrivances to regulate its motion under different temperatures, unless it could be shown that the earth's motion and the changes of temperature had been efficient causes of the motion and the adjustments of the watch; otherwise the argument would look altogether in the direction of design. Nor would it be fair to shut up the argument of design to the idea that the watch must have suddenly flashed into existence

fully formed and in motion. It would be quite as much a creation if slowly and laboriously made by the hand of the artificer, or if more rapidly struck off by machinery; and if the latter, it would not follow that the machine which produced the watch was at all like the watch itself. It might have been something very different. Finally, when Spencer tries to cut at the root of the whole of this argument, by affirming that man has no more right to reason from himself with regard to his Maker than a watch would have to reason from its own mechanical structure and affirm the like of its maker, he signally fails. If the watch had such power of reasoning, it would be more than mechanical, and would be intelligent like its maker; and in any case, if thus reasoning it came to the conclusion that it was a result of "accidental material operations," it would be altogether mistaken. Nor would it be nearer the truth if it held that it was a product of spontaneous evolution from an imperfect and comparatively useless watch that had been made millions of years before.

We have taken this illustration of the watch merely as given to us by Huxley, and without in the least seeking to overlook the distinction between a dead machine and a living organism; but the argument for creation and design is quite as strong in the case of the latter, so long as it cannot be proved by actual facts to be a product of derivation from a distinct species. This has not been proved either in the case of man or any other species; and so long as it has not,

the theory of creation and design is infinitely more rational and scientific than that of evolution in any of its forms.

But all this does not relieve us from the question, How can species be created?—the same question put to Paul by the sceptics of the first century with reference to the resurrection—“How are the dead raised, and with what bodies do they come?” I do not wish to evade this question, whether applied to man or to a microscopic animalcule, and I would answer it with the following statements:—

1. The advocate of creation is in this matter in no worse position than the evolutionist. This we have already shown, and I may refer here to the fact that Darwin himself assumes at least one primitive form of animal and plant life, and he is confessedly just as little able to imagine this one act of creation as any other that may be demanded of him.

2. We are not bound to believe that all groups of individual animals, which naturalists may call species, have been separate products of creation. Man himself has by some naturalists been divided into several species; but we may well be content to believe the creation of one primitive form, and the production of existing races by variation. Every zoologist and botanist who has studied any group of animals or plants with care, knows that there are numerous related forms passing into each other, which some naturalists might consider to be distinct species, but which it is certainly not necessary to regard as distinct

products of creation. Every species is more or less variable, and this variability may be developed by different causes. Individuals exposed to unfavourable conditions will be stunted and depauperated; those in more favourable circumstances may be improved and enlarged. Important changes may thus take place without transgressing the limits of the species, or preventing a return to its typical forms; and the practice of confounding these more limited changes with the wider structural and physiological differences which separate true species is much to be deprecated. Animals which pass through metamorphoses, or which are developed through the instrumentality of intermediate forms or "nurses,"* are not only liable to be separated by mistake into distinct species, but they may, under certain circumstances, attain to a premature maturity, or may be fixed for a time or permanently in an immature condition. Further, species, like individuals, probably have their infancy, maturity, and decay in geological time, and may present differences in these several stages. It is the remainder of true specific types left after all these sources of error are removed, that creation has to account for; and to arrive at this remainder, and to ascertain its nature and amount, will require a vast expenditure of skilful and conscientious labour.

3. Since animals and plants have been introduced upon our earth in long succession throughout geologic

* Mr. Mungo Ponton, in his book "The Beginning," has based a theory of derivation on this peculiarity.

time, and this in a somewhat regular manner, we have a right to assume that their introduction has been in accordance with a law or plan of creation, and that this may have included the co-operation of many efficient causes, and may have differed in its application to different cases. This is a very old doctrine of theology, for it appears in the early chapters of Genesis. There the first aquatic animals, and man, are said to have been "created;" plants are said to have been "brought forth by the land;" the mammalia are said to have been "made." In the more detailed account of the introduction of man in the second chapter of the same book, he is said to have been "formed of the dust of the ground;" and in regard to his higher spiritual life, to have had this "breathed into" him by God. These are very simple expressions, but they are very precise and definite in the original, and they imply a diversity in the creative work. Further, this is in accordance with the analogy of modern science. How diverse are the modes of production and development of animals and plants, though all under one general law; and is it not likely that the modes of their first introduction on the earth were equally diverse?

4. Our knowledge of the conditions of the origination of species, is so imperfect that we may possibly appear for some time to recede from, rather than to approach to, a solution of the question. In the infancy of chemistry, it was thought that chemical elements could be transmuted into each other. The

progress of knowledge removed this explanation of their origin, and has as yet failed to substitute any other in its place. It may be the same with organic species. The attempt to account for them by derivation may prove fallacious, yet it may be some time before we turn the corner, should this be possible, and enter the path which actually leads up to their origin.

Lastly, in these circumstances our wisest course is to take individual species, and to inquire as to their history in time, and the probable conditions of their introduction. Such investigations are now being made by many quiet workers, whose labours are comparatively little known, and many of whom are scarcely aware of the importance of what they are doing toward a knowledge of, at least, the conditions of creation, which is perhaps all that we can at present hope to reach.

In the next chapter we shall try to sum up what is known as to man himself, in the conditions of his first appearance on our earth, as made known to us by scientific investigation, and explained on the theory of creation as opposed to evolution.

CHAPTER XV.

PRIMITIVE MAN. CONSIDERED WITH REFERENCE TO MODERN THEORIES AS TO HIS ORIGIN—(*continued*).

IN the previous chapter we have seen that, on general grounds, evolution as applied to man is untenable; and that the theory of creation is more rational and less liable to objection. We may now consider how the geological and zoological conditions of man's advent on the earth accord with evolution; and I think we shall find, as might be expected, that they oppose great if not fatal difficulties to this hypothesis.

One of the first and most important facts with reference to the appearance of man, is that he is a very recent animal, dating no farther back in geological time than the Post-glacial period, at the close of the Tertiary and beginning of the Modern era of geology. Further, inasmuch as the oldest known remains of man occur along with those of animals which still exist, and the majority of which are probably not of older date, there is but slender probability that any much older human remains will ever be found. Now this has a bearing on the question of the derivation of man, which, though it has not altogether escaped the attention of the evolutionists, has not met with sufficient consideration.

Perhaps the oldest known human skull is that which has been termed the "Engis" skull, from the cave of Engis, in Belgium. With reference to this skull, Professor Huxley has candidly admitted that it may have belonged to an individual of one of the existing races of men. I have a cast of it on the same shelf with the skulls of some Algonquin Indians, from the aboriginal Hochelaga, which preceded Montreal; and any one acquainted with cranial characters would readily admit that the ancient Belgian may very well have been an American Indian; while on the other hand his head is not very dissimilar from that of some modern European races. This Belgian man is believed to have lived before the mammoth and the cave-bear had passed away, yet he does not belong to an extinct species or even variety of man.

Further, as stated in a previous chapter, Pictet catalogues ninety-eight species of mammals which inhabited Europe in the Post-glacial period. Of these fifty-seven still exist unchanged, and the remainder have disappeared. Not one can be shown to have been modified into a new form, though some of them have been obliged, by changes of temperature and other conditions, to remove into distant and now widely separated regions. Further, it would seem that all the existing European mammals extended back in geological time at least as far as man, so that since the Post-glacial period no new species have been introduced in any way. Here we have a series of facts of the most profound signifi-

cance. Fifty-seven parallel lines of descent have in Europe run on along with man, from the Post-glacial period, without change or material modification of any kind. Some of them extend without change even farther back. Thus man and his companion-mammals present a series of lines, not converging as if they pointed to some common progenitor, but strictly parallel to each other. In other words, if they are derived forms, their point of derivation from a common type is pushed back infinitely in geological time. The absolute duration of the human species does not affect this argument. If man has existed only six or seven thousand years, still at the beginning of his existence he was as distinct from lower animals as he is now, and shows no signs of gradation into other forms. If he has really endured since the great Glacial period, and is to be regarded as a species of a hundred thousand years' continuance, still the fact is the same, and is, if possible, less favourable to derivation.

Similar facts meet us in other directions. I have for many years occupied a little of my leisure in collecting the numerous species of molluscs and other marine animals existing in a sub-fossil state in the Post-pliocene clays of Canada, and comparing them with their modern successors. I do not know how long these animals have lived. Some of them certainly go far back into the Tertiary; and recent computations would place even the Glacial age at a distance from us of more than a thousand centuries. Yet after carefully studying about two hundred species, and, of some

of these, many hundreds of specimens, I have arrived at the conclusion that they are absolutely unchanged. Some of them, it is true, are variable shells, presenting as many and great varieties as the human race itself; yet I find that in the Post-pliocene even the varieties of each species were the same as now, though the great changes of temperature and elevation which have occurred, have removed many of them to distant places, and have made them become locally extinct in regions over which they once spread. Here again we have an absolute refusal, on the part of all these animals, to admit that they are derived, or have tended to sport into new species. This is also, it is to be observed, altogether independent of that imperfection of the geological record of which so much is made; since we have abundance of these shells in the Post-pliocene beds, and in the modern seas, and no one doubts their continued descent. To what does this point? Evidently to the conclusion that all these species show no indication of derivation, or tendency to improve, but move back in parallel lines to some unknown creative origin.

If it be objected to this conclusion that absence of derivation in the Post-pliocene and Modern does not prove that it may not previously have occurred, the answer is, that if the evolutionist admits that for a very long period (and this the only one of which we have any certain knowledge, and the only one which concerns man) derivation has been suspended, he in effect abandons his position. It may, however,

be objected that what I have above affirmed of species may be affirmed of varieties, which are admitted to be derived. For example, it may be said that the negro variety of man has existed unchanged from the earliest historic times. It is curious that those who so often urge this argument as an evidence of the great antiquity of man, and the slow development of races, do not see that it proves too much. If the negro has been the same identical negro as far back as we can trace him, then his origin must have been independent, and of the nature of a creation, or else his duration as a negro must have been indefinite. What it does prove is a fact equally obvious from the study of Post-pliocene molluscs and other fossils, namely, that new species tend rapidly to vary to the utmost extent of their possible limits, and then to remain stationary for an indefinite time. Whether this results from an innate yet limited power of expansion in the species, or from the relations between it and external influences, it is a fact inconsistent with the gradual evolution of new species. Hence we conclude that the recent origin of man, as revealed by geology, is, in connection with the above facts, an absolute bar to the doctrine of derivation.

A second datum furnished to this discussion by geology and zoology is the negative one that no link of connection is known between man and any preceding animal. If we gather his bones and his implements from the ancient gravel-beds and cave-earths, we do not find them associated with any

creature near of kin, nor do we find any such creature in those rich Tertiary beds which have yielded so great harvests of mammalian bones. In the modern world we find nothing nearer to him than such anthropoid apes as the orangs and gorillas. But the apes, however nearly allied, cannot be the ancestors of man. If at all related to him by descent, they are his brethren or cousins, not his parents; for they must, on the evolutionist hypothesis, be themselves the terminal ends of distinct lines of derivation from previous forms.

This difficulty is not removed by an appeal to the imperfection of the geological record. So many animals contemporary with man are known, both at the beginning of his geological history and in the present world, that it would be more than marvellous if no very near relative had ere this time been discovered at one extreme or the other, or at some portion of the intervening ages. Further, all the animals contemporary with man in the Post-glacial period, so far as is known, are in the same case. Discoveries of this kind may, however, still be made, and we may give the evolutionist the benefit of the possibility. We may affirm, however, that in order to gain a substratum of fact for his doctrine, he must find somewhere in the later Tertiary period animals much nearer to man than are the present anthropoid apes.

This demand I make advisedly—first, because the animals in question must precede man in geological

time; and secondly, because the apes, even if they preceded man, instead of being contemporary with him, are not near enough to fulfil the required conditions. What is the actual fact with regard to these animals, so confidently affirmed to resemble some not very remote ancestors of ours? Zoologically they are not varieties of the same species with man—they are not species of the same genus, nor do they belong to genera of the same family, or even to families of the same order. These animals are at least ordinarily distinct from us in those grades of groups in which naturalists arrange animals. I am well aware that an attempt has been made to group man, apes, and lemurs in one order of “Primates,” and thus to reduce their difference to the grade of the family; but as put by its latest and perhaps most able advocate, the attempt is a decided failure. One has only to read the concluding chapter of Huxley’s new book on the anatomy of the vertebrates to be persuaded of this, more especially if we can take into consideration, in addition to the many differences indicated, others which exist but are not mentioned by the author. Ordinal distinctions among animals are mainly dependent on grade or rank, and are not to be broken down by obscure resemblances of internal anatomy, having no relation to this point, but to physiological features of very secondary importance. Man must, on all grounds, rank much higher above the apes than they can do above any other order of mammals. Even if we refuse to recognise all higher grounds

of classification, and condescend, with some great zoologists of our time, to regard nature with the eyes of mere anatomists, or in the same way that a brick-layer's apprentice may be supposed to regard distinctions of architectural styles, we can arrive at no other conclusion. Let us imagine an anatomist, himself neither a man nor a monkey, but a being of some other grade, and altogether ignorant of the higher ends and powers of our species, to contemplate merely the skeleton of a man and that of an ape. He must necessarily deduce therefrom an ordinal distinction, even on the one ground of the correlations and modifications of structure implied in the erect position. It would indeed be sufficient for this purpose to consider merely the balancing of the skull on the neck, or the structure of the foot, and the consequences fairly deducible from either of them. Nay, were such imaginary anatomist a derivationist, and ignorant of the geological date of his specimens, and as careless of the differences in respect to brain as some of his human *confrères*, he might, referring to the less specialised condition of man's teeth and foot, conclude, not that man is an improved ape, but that the ape is a specialised and improved man. He would be obliged, however, even on this hypothesis, to admit that there must be a host of missing links. Nor would these be supplied by the study of the living races of men, because these want even specific distinctness, and differ from the apes essentially in those points on which an ordinal distinction can be fairly based.

This isolated position of man throughout the whole period of his history, grows in importance the more that it is studied, and can scarcely be the result of any accident of defective preservation of intermediate forms. In the meantime, when taken in connection with the fact previously stated, that man is equally isolated when he first appears on the stage, it deprives evolution, as applied to our species, of any precise scientific basis, whether zoological or geological.

I do not attach any importance whatever, in this connection, to the likeness in type or plan between man and other mammals. Evolutionists are in the habit of taking for granted that this implies derivation, and of reasoning as if the fact that the human skeleton is constructed on the same principles as that of an ape or a dog, must have some connection with a common ancestry of these animals. This is, however, as is usual with them, begging the question. Creation, as well as evolution, admits of similarity of plan. When Stephenson constructed a locomotive, he availed himself of the principles and of many of the contrivances of previous engines; but this does not imply that he took a mine-engine, or a marine-engine, and converted it into a railroad-engine. Type or plan, whether in nature or art, may imply merely a mental evolution of ideas in the maker, not a derivation of one object from another.

But while man is related in his type of structure to the higher animals, his contemporaries, it is undeniable that there are certain points in which he con-

stitutes a new type; and if this consideration were properly weighed, I believe it would induce zoologists, notwithstanding the proverbial humility of the true man of science, to consider themselves much more widely separated from the brutes than even by the ordinal distinction above referred to. I would state this view of the matter thus:—It is in the lower animals a law that the bodily frame is provided with all necessary means of defence and attack, and with all necessary protection against external influences and assailants. In a very few cases, we have partial exceptions to this. A hermit-crab, for instance, has the hinder part of its body unprotected; and has, instead of armour, the instinct of using the cast-off shells of molluses; yet even this animal has the usual strong claws of a crustacean, for defence in front. There are only a very few animals in which instinct thus takes the place of physical contrivances for defence or attack, and in these we find merely the usual unvarying instincts of the irrational animal. But in man, that which is the rare exception in all other animals, becomes the rule. He has no means of escape from danger, compared with those enjoyed by other animals—no defensive armour, no natural protection from cold or heat, no effective weapons for attacking other animals. These disabilities would make him the most helpless of creatures, especially when taken in connection with his slow growth and long immaturity. His safety and his dominion over other animals, are secured by entirely new means,

constituting a "new departure" in creation. Contrivance and inventive power, enabling him to utilise the objects and forces of nature, replace in him the material powers bestowed on lower animals. Obviously the structure of the human being is related to this, and so related to it as to place man in a different category altogether from any other animal.

This consideration makes the derivation of man from brutes difficult to imagine. None of these latter appear even able to conceive or understand the modes of life and action of man. They do not need to attempt to emulate his powers, for they are themselves provided for in a different manner. They have no progressive nature like that of man. Their relations to things without are altogether limited to their structures and instincts. Man's relations are limited only by his powers of knowing and understanding. How then is it possible to conceive of an animal which is, so to speak, a mere living machine, parting with the physical contrivances necessary to its existence, and assuming the new *rôle* of intelligence and free action?

This becomes still more striking if we adopt the view usually taken by evolutionists, that primitive man was a ferocious and carnivorous creature, warring with and overcoming the powerful animals of the Post-glacial period, and contending with the rigours of a severe climate. This could certainly not be inferred from his structure, interpreted by that of the lower animals, which would inevitably lead to the conclusion

that he must have been a harmless and frugivorous creature, fitted to subsist only in the mildest climates, and where exempt from the attacks of the more powerful carnivorous animals. No one reasoning on the purely physical constitution of man, could infer that he might be a creature more powerful and ferocious than the lion or the tiger.

It is also worthy of mention that the existence of primitive man as a savage hunter is, in another point of view, absolutely opposed to the Darwinian idea of his origin from a frugivorous ape. These creatures, while comparatively inoffensive, conform to the general law of lower animals in having strong jaws and powerful canines for defence, hand-like feet to aid them in securing food, and escaping from their enemies, and hairy clothing to protect them from cold and heat. On the hypothesis of evolution we might conceive that if these creatures were placed in some Eden of genial warmth, peace, and plenty, which rendered those appliances unnecessary, they might gradually lose these now valuable structures, from want of necessity to use them. But, on the contrary, if such creatures were obliged to contend against powerful enemies, and to feed on flesh, all analogy would lead us to believe that they would become in their structures more like carnivorous beasts than men. On the other hand, the anthropoid apes, in the circumstances in which we find them, are not only as unprogressive as other animals, but little fitted to extend their range, and less gifted with the power of adapt-

ing themselves to new conditions than many other mammals less resembling man in external form.

On the Darwinian theory, such primitive men as geology reveals to us would be more likely to have originated from bears than apes, and we would be tempted to wish that man should become extinct, and that the chance should be given to the mild chimpanzee or orang to produce by natural selection an improved and less ferocious humanity for the future.

The only rational hypothesis of human origin in the present state of our knowledge of this subject is, that man must have been produced under some circumstances in which animal food was not necessary to him, in which he was exempt from the attacks of the more formidable animals, and in less need of protection from the inclemency of the weather than is the case with any modern apes; and that his life as a hunter and warrior began after he had by his knowledge and skill secured to himself the means of subduing nature by force and cunning. This implies that man was from the first a rational being, capable of understanding nature, and it accords much more nearly with the old story of Eden in the book of Genesis, than with any modern theories of evolution.

It is due to Mr. Wallace—who, next to Darwin, has been a leader among English derivationists—to state that he perceives this difficulty. As a believer in natural selection, however, it presents itself to his mind in a peculiar form. He perceives that so soon as, by the process of evolution, man became a rational

creature, and acquired his social sympathies, physical evolution must cease, and must be replaced by invention, contrivance, and social organisation. This is at once obvious and undeniable, and it follows that the natural selection applicable to man, as man, must relate purely to his mental and moral improvement. Wallace, however, fails to comprehend the full significance of this feature of the case. Given, a man destitute of clothing, he may never acquire such clothing by natural selection, because he will provide an artificial substitute. He will evolve not into a hairy animal, but into a weaver and a tailor. Given, a man destitute of claws and fangs, he will not acquire these, but will manufacture weapons. But then, on the hypothesis of derivation, this is not what is given us as the raw material of man, but instead of this a hairy ape. Admitting the power of natural selection, we might understand how this ape could become more hairy, or acquire more formidable weapons, as it became more exposed to cold, or more under the necessity of using animal food; but that it should of itself leave this natural line of development and enter on the entirely different line of mental progress is not conceivable, except as a result of creative intervention.

Absolute materialists may make light of this difficulty, and may hold that this would imply merely a change of brain; but even if we admit this, they fail to show of what use such better brain would be to a creature retaining the bodily form and in-

instincts of the ape, or how such better brain could be acquired. But evolutionists are not necessarily absolute materialists, and Darwin himself labours to show that the reasoning self-conscious mind, and even the moral sentiments of man, might be evolved from rudiments of such powers, perceptible in the lower animals. Here, however, he leaves the court of natural science, properly so called, and summons us to appear before the judgment-seat of philosophy; and as naturalists are often bad mental philosophers, and philosophers have often small knowledge of nature, some advantage results, in the first instance, to the doubtful cause of evolution. Since, however, mental science makes much more of the distinctions between the mind of man and the instinct of animals than naturalists, accustomed to deal merely with the external organism, can be expected to do, the derivationist, when his plea is fairly understood, is quite as certain to lose his cause as when tried by geology and zoology. He might indeed be left to be dealt with by mental science on its own ground; and as our province is to look at the matter from the standpoint of natural history, we might here close our inquiry. It may, however, be proper to give some slight notion of the width of the gulf to be passed when we suppose the mechanical, unconscious, repetitive nature of the animal to pass over into the condition of an intellectual and moral being.

If we take, as the most favourable case for the evolutionist, the most sagacious of the lower animals

—the dog, for example—and compare it with the least elevated condition of the human mind, as observed in the child or the savage, we shall find that even here there is something more than that “immense difference in degree,” which Darwin himself admits. Making every allowance for similarities in external sense, in certain instinctive powers and appetites; and even in the power of comparison, and in certain passions and affections; and admitting, though we cannot be quite certain of this, that in these man differs from animals only in degree; there remain other and more important differences, amounting to the possession, on the part of man, of powers not existing at all in animals. Of this kind are—first, the faculty of reaching abstract and general truth, and consequently of reasoning, in the proper sense of the term; secondly, in connection with this, the power of indefinite increase in knowledge, and in deductions therefrom leading to practical results; thirdly, the power of expressing thought in speech; fourthly, the power of arriving at ideas of right and wrong, and thus becoming a responsible and free agent. Lastly, we have the conception of higher spiritual intelligence, of supreme power and divinity, and the consequent feeling of religious obligation. These powers are evidently different in kind, rather than in degree, from those of the brute, and cannot be conceived to have arisen from the latter, more especially as one of the distinctive characters of these is their purely cyclical, repetitive, and unprogressive nature.

Sir John Lubbock has, by a great accumulation of facts, or supposed facts, bearing on the low mental condition of savages, endeavoured to bridge over this chasm. It is obvious, however, from his own data, that the rudest savages are enabled to subsist only by the exercise of intellectual gifts far higher than those of animals; and that if these gifts were removed from them, they would inevitably perish. It is equally clear that even the lowest savages are moral agents; and that not merely in their religious beliefs and conceptions of good and evil, but also in their moral degradation, they show capacities not possessed by the brutes. It is also true that most of these savages are quite as little likely to be specimens of primitive man as are the higher races; and that many of them have fallen to so low a level as to be scarcely capable, of themselves, of rising to a condition of culture and civilisation. Thus they are more likely to be degraded races, in "the eddy and backwater of humanity," than examples of the sources from whence it flowed. And here it must not be lost sight of, that a being like man has capacities for degradation commensurate with his capacities for improvement; and that at any point of his history we may have to seek the analogues of primeval man, rather in the average, than the extremes of the race.

Before leaving this subject, it may be well to consider the fact, that the occurrence of such a being as man in the last stages of the world's history is, in

itself, an argument for the existence of a Supreme Creator. Man is himself an image and likeness of God; and the fact that he can establish relations with nature around him, so as to understand and control its powers, implies either that he has been evolved as a soul of nature, by its own blind development, or that he has originated in the action of a higher being related to man. The former supposition has been above shown to be altogether improbable; so that we are necessarily thrown back upon the latter. We must thus regard man himself as the highest known work of a spiritual creator, and must infer that he rightly uses his reason when he infers from nature the power and divinity of God.

The last point that I think necessary to bring forward here, is the information which geology gives as to the locality of the introduction of man. There can be no hesitation in affirming that to the temperate regions of the old continent belongs the honour of being the cradle of humanity. In these regions are the oldest historical monuments of our race; here geology finds the most ancient remains of human beings; here also seems to be the birthplace of the fauna and flora most useful and congenial to man; and here he attains to his highest pitch of mental and physical development. This, it is true, by no means accords with the methods of the derivationists. On their theory we should search for the origin of man rather in those regions where he is most depauperated and degraded, and where his struggles

for existence are most severe. But it is surely absurd to affirm of any species of animal or plant that it must have originated at the limits of its range, where it can scarcely exist at all. On the contrary, common sense as well as science requires us to believe that species must have originated in those central parts of their distribution where they enjoy the most favourable circumstances, and must have extended themselves thence as far as external conditions would permit. One of the most wretched varieties of the human race, and as near as any to the brutes, is that which inhabits Tierra del Fuego, a country which scarcely affords any of the means for the comfortable sustenance of man. Would it not be absolutely impossible that man should have originated in such a country? Is it not certain, on the contrary, that the Fuegian is merely a degraded variety of the aboriginal American race? Precisely the same argument applies to the Austral negro and the Hottentot. They are all naturally the most aberrant varieties of man, as being at the extreme range of his possible extension, and placed in conditions unfavourable, either because of unsuitable climatal or organic associations. It is true that the regions most favourable to the anthropoid apes, and in which they may be presumed to have originated, are by no means the most favourable to man; but this only makes it the less likely that man could have been derived from such a parentage.

While, therefore, the geological date of the appear-

ance of man, the want of any link of connection between him and any preceding animal, and his dissimilar bodily and mental constitution from any creatures contemporary with him, render his derivation from apes or other inferior animals in the highest degree improbable, the locality of his probable origin confirms this conclusion in the strongest manner. It also shows that man and the higher apes are not likely to have originated in the same regions, or under the same conditions, and that the conditions of human origin are rather the coincidence of suitable climatal and organic surroundings than the occurrence of animals closely related in structure to man.

Changes of conditions in geological time will not meet this difficulty. They might lead to migrations, as they have done in the case of both plants and animals, but not to anything further. The hyena, whose bones are found in the English caves, has been driven by geological changes to South Africa, but he is still the same hyena. The reindeer which once roamed in France is still the reindeer in Lapland; and though under different geological conditions we might imagine the creature to have originated in the south of Europe, a country not now suitable to it, this would neither give reason to believe that any animal now living in the south of Europe was its progenitor, nor to doubt that it still remains unchanged in its new habitat. Indeed, the absence of anything more than merely varietal change in man and his companion-animals, in con-

sequence of the geological changes and migrations of the Modern period, furnishes, as already stated, a strong if not conclusive argument against derivation; which here, as elsewhere, only increases our actual difficulties, while professing to extricate us from them.

The arguments in the preceding pages cover only a small portion of the extensive field opened up by this subject. They relate, however, to some of the prominent and important points, and I trust are sufficient to show that, as applied to man, the theory of derivation merely trifles with the great question of his origin, without approaching to its solution. I may now, in conclusion, sketch the leading features of primitive man, as he appears to us through the mist of the intervening ages, and compare the picture with that presented by the oldest historical records of our race.

Two pictures of primeval man are in our time before the world. One represents him as the pure and happy inhabitant of an Eden, free from all the ills that have afflicted his descendants, and revelling in the bliss of a golden age. This is the representation of Holy Scripture, and it is also the dream of all the poetry and myth of the earlier ages of the world. It is a beautiful picture, whether we regard it as founded on historical fact, or derived from God Himself, or from the yearnings of the higher spiritual nature of man. The other picture is a joint product

of modern philosophy and of antiquarian research. It presents to us a coarse and filthy savage, repulsive in feature, gross in habits, warring with his fellow-savages, and warring yet more remorselessly with every living thing he could destroy, tearing half-cooked flesh, and cracking marrow-bones with stone hammers, sheltering himself in damp and smoky caves, with no eye heavenward, and with only the first rude beginnings of the most important arts of life.

Both pictures may contain elements of truth, for man is a many-sided monster, made up of things apparently incongruous, and presenting here and there features out of which either picture may be composed. Evolutionists, and especially those who believe in the struggle for existence and natural selection, ignore altogether the evidence of the golden age of humanity, and refer us to the rudest of modern savages as the types of primitive man. Those who believe in a Divine origin for our race, perhaps dwell too much on the higher spiritual features of the Edenic state, to the exclusion of its more practical aspects, and its relations to the condition of the more barbarous races. Let us examine more closely both representations; and first, that of creation.

The Glacial period, with its snows and ice, had passed away, and the world rejoiced in a spring-time of renewed verdure and beauty. Many great and formidable beasts of the Tertiary time had disappeared in the revolutions which had occurred, and

the existing fauna of the northern hemisphere had been established on the land. Then it was that man was introduced by an act of creative power. In the preceding changes a region of Western Asia had been prepared for his residence. It was a table-land at the head waters of the rivers that flow into the Euxine, the Caspian, and the Persian Gulf. Its climate was healthy and bracing, with enough of variety to secure vigour, and not so inclement as to exact any artificial provision for clothing or shelter. Its flora afforded abundance of edible fruits, and was rich in all the more beautiful forms of plant life; while its clear streams, alluvial soil, and undulating surface, afforded every variety of station and all that is beautiful in scenery. It was not infested with the more powerful and predacious quadrupeds, and its geographical relations were such as to render this exemption permanent. In this paradise man found ample supplies of wholesome and nutritious food. His requirements as to shelter were met by the leafy bowers he could weave. The streams of Eden afforded gold which he could fashion for use and ornament, pearly shells for vessels, and agate for his few and simple cutting instruments. He required no clothing, and knew of no use for it. His body was the perfection and archetype of the vertebrate form, full of grace, vigour, and agility. His hands enabled him to avail himself of all the products of nature for use and pleasure, and to modify and adapt them according to his inclination. His intelligence,

along with his manual powers, allowed him to ascertain the properties of things, to plan, invent, and apply in a manner impossible to any other creature. His gift of speech enabled him to imitate and reduce to systematic language the sounds of nature, and to connect them with the thoughts arising in his own mind, and thus to express their relations and significance. Above all, his Maker had breathed into him a spiritual nature akin to His own, whereby he became different from all other animals, and the very shadow and likeness of God; capable of rising to abstractions and general conceptions of truth and goodness, and of holding communion with his Creator. This was man Edenic, the man of the golden age, as sketched in the two short narratives of the earlier part of Genesis, which not only conform to the general traditions of our race on the subject, but bear to any naturalist who will read them in their original dress, internal evidence of being contemporary, or very nearly so, with the state of things to which they relate.

“And God said, ‘Let us make man in our image, after our likeness; and let them rule over the fish of the sea, and over the birds of the air, and over the herbivora, and over all the land.’ And God blessed them, and said unto them, ‘Be fruitful and multiply, and fill the earth and subdue it.’

“And the Lord God formed the man of the dust of the ground, and breathed into his nostrils the breath of life, and man became a living being. And the Lord God planted a garden, eastward in Eden, and there He placed the man whom He had formed. And out of the ground made the Lord God to grow every tree that is pleasant to the sight and good for

food. And a river went out of Eden to water the garden, and parted from thence, becoming four heads (of great rivers). The name of the first is Pison, compassing the whole land of Chavila, where there is gold, and the gold of that land is good; there is (also) pearl and agate. . . . And the Lord God took the man, and put him into the garden of Eden, to cultivate it and to take care of it."

Before leaving this most ancient and most beautiful history, we may say that it implies several things of much importance to our conceptions of primeval man. It implies a centre of creation for man, and a group of companion animals and plants, and an intention to dispense in his case with any struggle for existence. It implies, also, that man was not to be a lazy savage, but a care-taker and utiliser, by his mind and his bodily labour, of the things given to him; and it also implies an intelligent submission on his part to his Maker, and spiritual appreciation of His plans and intentions. It further implies that man was, in process of time, from Eden, to colonise the earth, and subdue its wildness, so as to extend the conditions of Eden widely over its surface. Lastly, a part of the record not quoted above, but necessary to the consistency of the story, implies that, in virtue of his spiritual nature, and on certain conditions, man, though in bodily frame of the earth earthy, like the other animals, was to be exempted from the common law of mortality which had all along prevailed, and which continued to prevail, even among the animals of Eden. Further, if man fell from this condition into that of the savage of the age of stone, it must have been by the obscuration of his

spiritual nature under that which is merely animal; in other words, by his ceasing to be spiritual and in communion with God, and becoming practically a sensual materialist. That this actually happened is asserted by the Scriptural story, but its details would take us too far from our present subject. Let us now turn to the other picture—that presented by the theory of struggle for existence and derivation from lower animals.

It introduces us first to an ape, akin perhaps to the modern orang or gorilla, but unknown to us as yet by any actual remains. This creature, after living for an indefinite time in the rich forests of the Miocene and earlier Pliocene periods, was at length subjected to the gradually increasing rigours of the Glacial age. Its vegetable food and its leafy shelter failed it, and it learned to nestle among such litter as it could collect in dens and caves, and to seize and devour such weaker animals as it could overtake and master. At the same time, its lower extremities, no longer used for climbing trees, but for walking on the ground, gained in strength and size; its arms diminished; and its development to maturity being delayed by the intensity of the struggle for existence, its brain enlarged, it became more cunning and sagacious, and even learned to use weapons of wood or stone to destroy its victims. So it gradually grew into a fierce and terrible creature, "neither beast nor human," combining the habits of a bear and the agility of a monkey with some glimmerings of the cunning and resources of a savage.

When the Glacial period passed away, our nameless simian man, or manlike ape, might naturally be supposed to revert to its original condition, and to establish itself as of old in the new forests of the Modern period. For some unknown reason, however, perhaps because it had gone too far in the path of improvement to be able to turn back, this reversion did not take place. On the contrary, the ameliorated circumstances and wider range of the new continents enabled it still further to improve. Ease and abundance perfected what struggle and privation had begun; it added to the rude arts of the Glacial time; it parted with the shaggy hair now unnecessary; its features became softer; and it returned in part to vegetable food. Language sprang up from the attempt to articulate natural sounds. Fire-making was invented and new arts arose. At length the spiritual nature, potentially present in the creature, was awakened by some access of fear, or some grand and terrible physical phenomenon; the idea of a higher intelligence was struck out, and the descendant of apes became a superstitious and idolatrous savage. How much trouble and discussion would have been saved, had he been aware of his humble origin, and never entertained the vain imagination that he was a child of God, rather than a mere product of physical evolution! It is, indeed, curious, that at this point evolutionism, like theism, has its "fall of man;" for surely the awakening of the religious sense, and of the knowledge of good and evil, must on that theory be so

designated, since it subverted in the case of man the previous regular operation of natural selection, and introduced all that debasing superstition, priestly domination, and religious controversy which have been among the chief curses of our race, and which are doubly accursed if, as the evolutionist believes, they are not the ruins of something nobler and holier, but the mere gratuitous, vain, and useless imaginings of a creature who should have been content to eat and drink and die, without hope or fear, like the brutes from which he sprang.

These are at present our alternative sketches: the genesis of theism, and the genesis of evolution. After the argument in previous pages, it is unnecessary here to discuss their relative degrees of probability. If we believe in a personal spiritual Creator, the first becomes easy and natural, as it is also that which best accords with history and tradition. If, on the contrary, we reject all these, and accept as natural laws the postulates of the evolutionists which we have already discussed, we may become believers in the latter. The only remaining point is to inquire as to which explains best the actual facts of humanity as we find them. This is a view of which much has been made by evolutionists, and it therefore merits consideration. But it is too extensive to be fully treated of here, and I must content myself with a few illustrations of the failure of the theory of derivation to explain some of the most important features presented by even the ruder races of men.

One of these is the belief in a future state of existence beyond this life. This belongs purely to the spiritual nature of man. It is not taught by physical nature, yet its existence is probably universal, and it lies near the foundation of all religious beliefs. Lartet has described to us the sepulchral cave of Aurignac, in which human skeletons, believed to be of Post-glacial date, were associated with remains of funeral feasts, and with indications of careful burial, and with provisions laid up for the use of the dead. Lyell well remarks on this, "If we have here before us, at the northern base of the Pyrenees, a sepulchral vault with skeletons of human beings, consigned by friends and relatives to their last resting-place—if we have also at the portal of the tomb the relics of funeral feasts, and within it indications of viands destined for the use of the departed on their way to a land of spirits; while among the funeral gifts are weapons wherewith in other fields to chase the gigantic deer, the cave-lion, the cave-bear, and woolly rhinoceros—we have at last succeeded in tracing back the sacred rites of burial, and more interesting still, a belief in a future state, to times long anterior to those of history and tradition. Rude and superstitious as may have been the savage of that remote era, he still deserved, by cherishing hopes of a hereafter, the epithet of 'noble,' which Dryden gave to what he seems to have pictured to himself as the primitive condition of our race."*

In like manner, in the vast American continent, all

* "Antiquity of Man," p. 192.

its long isolated and widely separated tribes, many of them in a state of lowest barbarism, and without any external ritual of religious worship, believed in happy hunting-grounds in the spirit-land beyond the grave, and the dead warrior was buried with his most useful weapons and precious ornaments.

“Bring here the last gifts; and with them
The last lament be said.
Let all that pleased and yet may please,
Be buried with the dead”

was no unmeaning funeral song, but involved the sacrifice of the most precious and prized objects, that the loved one might enter the new and untried state provided for its needs. Even the babe, whose life is usually accounted of so small value by savage tribes, was buried by the careful mother with precious strings of wampum, that had cost more months of patient labour than the days of its short life, that it might purchase the fostering care of the inhabitants of that unknown yet surely believed-in region of immortality. This

“—wish that of the living whole
No life may fail beyond the grave,
Derives it not from what we have
The likest God within the sou

Is it likely to have germinated in the brain of an ape? and if so, of what possible use would it be in the struggle of a merely physical existence? Is it not rather the remnant of a better spiritual life—a remembrance of the tree of life that grew in the

paradise of God, a link of connection of the spiritual nature in man with a higher Divine Spirit above? Life and immortality, it is true, were brought to light by Jesus Christ, but they existed as beliefs more or less obscure from the first, and formed the basis for good and evil of the religions of the world. Around this idea were gathered multitudes of collateral beliefs and religious observances; feasts and festivals for the dead; worship of dead heroes and ancestors; priestly intercessions and sacrifices for the dead; costly rites of sepulture. Vain and without foundation many of these have no doubt been, but they have formed a universal and costly testimony to an instinct of immortality, dimly glimmering even in the breast of the savage, and glowing with higher brightness in the soul of the Christian, but separated by an impassable gulf from anything derivable from a brute ancestry.

The theistic picture of primeval man is in harmony with the fact that men, as a whole, are, and always have been, believers in God. The evolutionist picture is not. If man had from the first not merely a physical and intellectual nature, but a spiritual nature as well, we can understand how he came into relation with God, and how through all his vagaries and corruptions he clings to this relation in one form or another; but evolution affords no link of connection of this kind. It holds God to be unknowable even to the cultivated intellect of philosophy, and perceives no use in ideas with relation to Him,

which according to it must necessarily be fallacious. It leaves the theistic notions of mankind without explanation, and it will not serve its purpose to assert that some few and exceptional families of men have no notion of a God. Even admitting this, and it is at best very doubtful, it can form but a trifling exception to a general truth.

It appears to me that this view of the case is very clearly put in the Bible, and it is curiously illustrate by a recent critique of "Mr. Darwin's Critics," by Professor Huxley in the *Contemporary Review*. Mr. Mivart, himself a derivationist, but differing in some points from Darwin, had affirmed, in the spirit rather of a Romish theologian than of a Biblical student or philosopher, that "acts unaccompanied by mental acts of conscious will" are "absolutely destitute of the most incipient degree of goodness." Huxley well replies, "It is to my understanding extremely hard to reconcile Mr. Mivart's dictum with that noble summary of the whole duty of man, 'Thou shalt love the Lord thy God with all thy heart, and with all thy soul, and with all thy strength; and thou shalt love thy neighbour as thyself.' According to Mr. Mivart's definition, the man who loves God and his neighbour, and, out of sheer love and affection for both, does all he can to please them, is nevertheless destitute of a particle of real goodness." Huxley's reply deserves to be pondered by certain moralists and theologians whose doctrine savours of the leaven of the Pharisees, but neither Huxley nor

his opponent see the higher truth that in the love of God we have a principle far nobler and more God-like and less animal than that of mere duty. Man primeval, according to the doctrine of Genesis, was, by simple love and communion with his God, placed in the position of a spiritual being, a member of a higher family than that of the animal. The "knowledge of good and evil" which he acquired later, and on which is based the law of conscious duty, was a less happy attainment, which placed him on a lower level than that of the unconscious love and goodness of primal innocence. No doubt man's sense of right and wrong is something above the attainment of animals, and which could never have sprung from them; but still more is this the case with his direct spiritual relation to God, which, whether it rises to the inspiration of the prophet or the piety of the Christian, or sinks to the rude superstition of the savage, can be no part of the Adam of the dust but only of the breath of life breathed into him from above.

That man should love his fellow-man may not seem strange. Certain social and gregarious and family instincts exist among the lower animals, and Darwin very ably adduces these as akin to the similar affections of man; yet even in the law of love of our neighbour, as enforced by Christ's teaching, it is easy to see that we have something beyond animal nature. But this becomes still more distinct in the love of God. Man was the "shadow and likeness of God," says the old

record in Genesis—the shadow that clings to the substance and is inseparable from it, the likeness that represents it visibly to the eyes of men, and of the animals that man rules over. Primeval man could “hear in the evening breeze the voice of God, walking to and fro in the garden.” What mere animal ever had or could attain to such an experience?

But if we turn from the Edenic picture of man in harmony with Heaven—“owning a father, when he owned a God”—to man as the slave of superstition; even in this terrible darkness of mistaken faith, of which it may be said,

“Fear makes her devils, and weak faith her gods,
 Gods partial, changeful, passionate, unjust,
 Whose attributes are gain, revenge, or lust,”

we see the ruins, at least, of that sublime love of God. The animal clings to its young with a natural affection, as great as that of a human mother for her child, but what animal ever thought of throwing its progeny into the Ganges, or into the fires of Moloch’s altar, for the saving of its soul, or to obtain the favour or avoid the wrath of God? No less in the vagaries of fetichism, ritualism, and idolatry, and in the horrors of asceticism and human sacrifice, than in the Edenic communion with and hearing of God, or in the joy of Christian love, do we see, in however ruined or degraded condition, the higher spiritual nature of man.

This point leads to another distinction which, when properly viewed, widens the gap between man and

the animals, or at least destroys one of the frail bridges of the evolutionists. Lubbock and others affect to believe that the lowest savages of the modern world must be nearest to the type of primeval man. I have already attempted to show the fallacy of this. I may add here that in so holding they overlook a fundamental distinction, well pointed out by the Duke of Argyll, between the capacity of acquiring knowledge and knowledge actually acquired, and between the possession of a higher rational nature and the exercise of that nature in the pursuit of mechanical arts. In other words, primeval man must not be held to have been "utterly barbarous" because he was ignorant of mining or navigation, or of sculpture and painting. He had in him the power to attain to these things, but so long as he was not under necessity to exercise it, his mind may have expended its powers in other and happier channels. As well might it be affirmed that a delicately nurtured lady is an "utter barbarian" because she cannot build her own house, or make her own shoes. No doubt in such work she would be far more helpless than the wife of the rudest savage, yet she is not on that account to be held as an inferior being, or nearer to the animals. Our conception of an angelic nature implies the absence of all our social institutions and mechanical arts; but does this necessitate our regarding an angel as an "utter barbarian"? In short, the whole notion of civilisation held by Lubbock and those who think with him, is not only low and degrading, but utterly

and absurdly wrong; and of course it vitiates all their conceptions of primeval man as well as of man's future destiny. Further, the theistic idea implies that man was, without exhausting toil, to regulate and control nature, to rule over the animals, to cultivate the earth, to extend himself over it and subdue it; and all this as compatible with moral innocence, and at the same time with high intellectual and spiritual activity.

There is, however, a still nicer and more beautiful distinction involved in this, and included in the wonderful narrative in Genesis, so simple yet so much more profound than our philosophies; and which crops out in the same discussion of the critics of Darwin, to which I have already referred. A writer in the *Quarterly Review* had attempted to distinguish human reason from the intelligence of animals, as involving self-consciousness and reflection in our sensations and perceptions. Huxley objects to this, instancing the mental action of a greyhound when it sees and pursues a hare, as similar to that of the gamekeeper when he lets slip the hound.*

“As it is very necessary to keep up a clear distinction between these two processes, let the one be called neurosis and the other psychosis. When the gamekeeper was first trained to his work, every step in the process of neurosis was accompanied by a corresponding step in that of psychosis, or nearly so.

* *Contemporary Review*, November, 1871, p. 461.

He was conscious of seeing something, conscious of making sure it was a hare, conscious of desiring to catch it, and therefore to loose the greyhound at the right time, conscious of the acts by which he let the dog out of the leash. But with practice, though the various steps of the neurosis remain—for otherwise the impression on the retina would not result in the loosing of the dog—the great majority of the steps of the psychosis vanish, and the loosing of the dog follows unconsciously, or, as we say, without thinking about, upon the sight of the hare. No one will deny that the series of acts which originally intervened between the sensation and the letting go of the dog were, in the strictest sense, intellectual and rational operations. Do they cease to be so when the man ceases to be conscious of them? That depends upon what is the essence and what the accident of these operations, which taken together constitute ratiocination. Now, ratiocination is resolvable into predication, and predication consists in marking, in some way, the existence, the co-existence, the succession, the likeness and unlikeness, of things or their ideas. Whatever does this, reasons; and if a machine produces the effects of reason, I see no more ground for denying to it the reasoning power because it is unconscious, than I see for refusing to Mr. Babbage's engine the title of a calculating machine on the same grounds."

Here we have in the first place, the fact that an action, in the first instance rational and complex, be-

comes by repetition simple and instinctive. Does the man then sink to the level of the hound, or, what is more to the purpose, does this in the least approach to showing that the hound can rise to the level of the man? Certainly not; for the man is the conscious planner and originator of a course of action in which the instincts of the brute are made to take part, and in which the readiness that he attains by habit only enables him to dispense with certain processes of thought which were absolutely necessary at first. The man and the beast co-operate, but they meet each other from entirely different planes; the former from that of the rational consideration of nature, the latter from that of the blind pursuit of a mere physical instinct. The one, to use Mr. Huxley's simile, is the conscious inventor of the calculating machine, the other is the machine itself, and, though the machine can calculate, this fact is the farthest possible from giving it the power of growing into or producing its own inventor. But Moses, or the more ancient authority from whom he quotes in Genesis, knew this better than either of these modern combatants. His special distinctive mark of the superiority of man is that he was to have dominion over the earth and its animal inhabitants; and he represents this dominion as inaugurated by man's examining and naming the animals of Eden, and finding among them no "help meet" for him.* Man was to find in them helps, but helps under his control, and that not the control

* Literally, "Corresponding," or "Similar," to him.

of brute force, but of higher skill and of thought, and even of love—a control still seen in some degree in the relation of man to his faithful companion, the dog. These old words of Genesis, simple though they are, place the rational superiority of man on a stable basis, and imply a distinction between him and the lower animals which cannot be shaken by the sophistries of the evolutionists.

The theistic picture further accords with the fact that the geological time immediately preceding man's appearance was a time of decadence of many of the grander forms of animal life, especially in that area of the old continent where man was to appear. Whatever may be said of the imperfection of the geological record, there can be no question of the fact that the Miocene and earlier Pliocene were distinguished by the prevalence of grand and gigantic forms of mammalian life, some of which disappeared in or before the Glacial period, while others failed after that period in the subsidence of the Post-glacial, or in connection with its amelioration of climate. The Modern animals are also, as explained above, a selection from the grander fauna of the Post-glacial period. To speak for the moment in Darwinian language, there was for the time an evident tendency to promote the survival of the fittest, not in mere physical development, but in intelligence and sagacity. A similar tendency existed even in the vegetable world, replacing the flora of American aspect which had existed in the Pliocene, with the richer and more

useful flora of Europe and Western Asia. This not obscurely indicates the preparing of a place for man, and the removal out of his way of obstacles and hindrances. That these changes had a relation to the advent of man, neither theist nor evolutionist can doubt, and it may be that we shall some day find that this relation implies the existence of a creative law intelligible by us; but while we fail to perceive any link of direct causation between the changes in the lower world, and the introduction of our race, we cannot help seeing that correlation which implies a far-reaching plan, and an intelligent design.

Finally, the evolutionist picture wants some of the fairest lineaments of humanity, and cheats us with a semblance of man without the reality. Shave and paint your ape as you may, clothe him and set him up upon his feet, still he fails greatly of the "human form divine;" and so it is with him morally and spiritually as well. We have seen that he wants the instinct of immortality, the love of God, the mental and spiritual power of exercising dominion over the earth. The very agency by which he is evolved is of itself subversive of all these higher properties. The struggle for existence is essentially selfish, and therefore degrading. Even in the lower animals, it is a false assumption that its tendency is to elevate; for animals when driven to the utmost verge of struggle for life, become depauperated and degraded. The dog which spends its life in snarling contention with its fellow-curs for insufficient food, will not be a noble

specimen of its race. God does not so treat His creatures. There is far more truth to nature in the doctrine which represents him as listening to the young ravens when they cry for food. But as applied to man, the theory of the struggle for existence and survival of the fittest, though the most popular phase of evolutionism at present, is nothing less than the basest and most horrible of superstitions. It makes man not merely carnal, but devilish. It takes his lowest appetites and propensities, and makes them his God and creator. His higher sentiments and aspirations, his self-denying philanthropy, his enthusiasm for the good and true, all the struggles and sufferings of heroes and martyrs, not to speak of that self-sacrifice which is the foundation of Christianity, are in the view of the evolutionist mere loss and waste, failure in the struggle of life. What does he give us in exchange? An endless pedigree of bestial ancestors, without one gleam of high or holy tradition to enliven the procession; and for the future, the prospect that the poor mass of protoplasm which constitutes the sum of our being, and which is the sole gain of an indefinite struggle in the past, must soon be resolved again into inferior animals or dead matter. That men of thought and culture should advocate such a philosophy, argues either a strange mental hallucination, or that the higher spiritual nature has been wholly quenched within them. It is one of the saddest of many sad spectacles that our age presents. Still these men deserve credit for their

bold pursuit of truth, or what seems to them to be truth; and they are, after all, nobler sinners than those who would practically lower us to the level of beasts by their negation even of intellectual life, or who would reduce us to apes, by making us the mere performers of rites and ceremonies, as a substitute for religion, or who would advise us to hand over reason and conscience to the despotic authority of fallible men dressed in strange garbs, and called by sacred names. The world needs a philosophy and a Christianity of more robust mould, which shall recognise, as the Bible does, at once body and soul and spirit, at once the sovereignty of God and the liberty of man; and which shall bring out into practical operation the great truth that God is a Spirit, and they that worship Him must worship Him in spirit and in truth. Such a religion might walk in the sunlight of truth and free discussion, hand in hand with science, education, liberty, and material civilisation, and would speedily consign evolution to the tomb which has already received so many superstitions and false philosophies.

INDEX.

- Abbeville, Peat of, 294.
 Acadian Group, 38.
 Advent of Man, 286.
 Agassiz on Synthetic Types, 181.
Ammonitidæ, 221.
 Amphibians of the Coal Period, 144.
 Andrews on the Post-pliocene, 293.
Anthracosaurus, 145.
 Anticosti Formation, 61.
 Antiquity of Man, 292.
Archæocyathus, 47.
 Archebiosis, 327.
Arenicolites, 46.
Asterolepis, 98.
- Baculites*, 222.
 Bala Limestone, 59.
Baphetes, 145.
 Barrande on Primordial, 49.
 Bastian on Lower forms of Life, 327.
Beatricea, 65.
Belemnites, 223.
 Bigsby on Silurian Fauna, 75; on Primordial Life, 52.
 Billings on *Archæocyathus*, 46; on Feet of Trilobites, 44.
 Binney on *Stigmaria*, 127.
 Biology as a term, 327.
 Boulder Clay, 268.
 Brachiopods, or Lamp-shells, 39.
 Breccia of Caverns, 304.
 Brown, Mr. R., on *Stigmaria*, 127.
- Calamites*, 104, 129, 173.
 Calcaire Grossier, 247.
 Cambrian Age, 36; name defined, 49.
 Caradoc Rocks, 60.
 Carbonic Acid in Atmosphere, 123.
 Carboniferous Age, 109; Land Quails of the, 138; Crustaceans of the, 154; Insects of the, 135; Corals of the, 153; Plants of the, 120; Fishes of the, 157; Footprints in the, 143; Geography of the, 110; Reptiles of the, 143.
 Carpenter on Cretaceous Sea, 230.
 Carruthers on Graptolites, 72.
 Cave Earth, 305.
 Cavern Deposits, 304.
Cephalaspis, 97.
 Cephalopods of Silurian, 69.
Ceteosaurus, 204; Foraminifera in the, 227.
 Chalk, Nature of, 227.
 Chaos, 2.
Climactichmites, 45.
 Coal, Origin of, 116; of the Mesozoic, 201.
 Colours of Rocks, 110.
 Continental Plateaus, 57.
 Continents, their Origin, 13.
Conulus Priscus, 139.
 Cope on Dinosaurs, 202; on Pterodactyl, 206; on Mososaurus, 217; on Caverns, 303.
 Corals of the Silurian, 63; agency of, in forming Limestone, 63, 89; of the Devonian, 89; of the Carboniferous, 153.
 Corniferous Limestone, 96.
Coryphodon, 244.
 Creation, Unity of, 33; not by Evolution, 33; laws of, 78, 150; statement of as a theory, 340; requirements of, 343; how treated by Evolutionists, 339; definition and explanation of, 340; its probable conditions, 352.
 Creator, evidence of a personal, 344.

- Cretaceous Period, 192, 231; Sea of the, 230.
 Crinoids of the Silurian, 68.
 Croll on the Post-pliocene, 262.
Crusiana, 45.
 Crustaceans of the Primordial, 42; of the Silurian, 71; of the Mesozoic, 225.
 Crust of the Earth, 5; Folding of, 165.
 Cuvier on Tertiary Mammals, 249.
 Cystideans, 69.
 Dana on Geological Periods, 175.
 Darwin, Nature of his Theory, 327; his account of the Origin of Man, 337; his statement of Descent of Man, 337.
 Davidson on Brachiopods, 169.
 Dawkins on Post-glacial Mammals, 300.
 Delaunay on Solidity of the Earth, 6.
 Deluge, the, 290.
 Devonian, or Erian Age, 81; Physical Condition of, 82; Tabular View of, 85; Corals of the, 89; Fishes of the, 96; Plants of the, 102; Geography of the, 82; Insects of the, 107.
Dinichthys, 99.
 Dinosaurs, 202.
Dromatherium, 208.
 Dudley, Fossils of, 69.
 Earth, its earliest state, 9; Crust of the, 5; folding of, 165; gaseous state of, 9.
 Edenic state of Man, 310, 376.
 Edwards, Milne, on Devonian Corals, 89.
Elasmosaurus, 214.
 Elephants, Fossil, 254, 300.
 Elevation and Subsidence, 13, 29, 83, 165.
 Enaliosaurs, 213.
 "Engis" Skull, its characters, 357.
 Eocene Seas, 241; Foraminifera of the, 241; Mammals of the, 247; Plants of the, 238; Footprints in the, 299.
Eophyton, 42.
Eosaurus, 145.
 Eozoic Period, 17.
Eozoon Bavaricum, 38.
Eozoon Canadense, 20, 24.
 Erian, or Devonian, 81; Reason of the Name, 84; Table of Erian Formations, 85; Corals of the, 89; Fishes of the, 96; Plants of the, 102.
 Eskers on Kames, 286.
 Etheridge on Devonian, 85.
Eurypterus, 71, 115.
 Evolution as applied to Eozoon, 33; Primordial Animals, 55; Silurian Animals, 77; Trilobites, 94, 155; Reptiles, 150; Man, 319; Its Character as a Theory, 320; Its Difficulties, 322; Its "Fall of Man," 382.
 Falconer on Indian Miocene, 252.
Favosites, 91.
 Ferns of the Devonian, 96; of the Carboniferous, 120.
 Fishes, Ganoid, 99; of the Silurian, 74; of the Devonian, 96; of the Carboniferous, 157.
 Flora of the Silurian, 76; of the Devonian, 102; of the Carboniferous, 120; of the Permian, 172; of the Mesozoic, 199; of the Eocene, 238; of the Miocene, 259.
 Footprints in the Carboniferous, 143; in the Trias, 203; in the Eocene, 297.
 Foraminifera, Nature of, 24; Laurentian, 25; of the Chalk, 227; of the Tertiary, 241.
 Forbes on Post-glacial Land, 288.
 Forests of the Devonian, 102; of the Carboniferous, 120.
 Ganoid Fishes, 96, 99.
 Gaseous state of the Earth, 9.
 Genesis, Book of, its account of Chaos, 2; of Creation of Land, 13; of Palæozoic Animals, 187; of Creation of Reptiles, 150; of Creation of Mammals, 234, 298; of the Deluge, 290; of Creation of Man, 379; of Eden, 379.
 Genesis of the Earth, 1.

- Geography of the Silurian, 57 ; of the Devonian, 82 ; of the Carboniferous, 110 ; of the Permian, 163.
 Geological Periods, 175, 195.
 Glacial Period, 267, 278.
 Glauconite, 229.
Glyptocrurus, 88.
 Graptolites, 72.
 Greenland, Miocene Flora of, 260.
 Greensand, 229.
 Gumbel on Bavarian Eozoon, 37.
Hadrosaurus, 202.
 Hall on Geological Periods, 186.
 Hall on Graptolites, 72 ; on Geological Periods, 186.
 Harlech Beds, 38.
 Heer on Tertiary Plants, 261.
 Helderberg Rocks, 62.
 Hercynian Schists, 37.
 Heterogenesis, 327.
 Hicks on Primordial Fossils, 38.
 Hilgard on Mississippi Delta, 296.
 Hippopotamus, Fossil, 300.
Histioderma, 46.
 Hopkins on Solidity of the Earth, 6.
 Hudson River Group, 60.
 Hunt, Dr. T. S., on Volcanic Action, 7 ; on Chemistry of Primeval Earth, 11 ; on *Lingulæ*, 41.
 Huronian Formation, 36.
 Huxley on Coal, 132 ; on Carboniferous Reptiles, 145 ; on Dinosaurs, 202 ; on Paley's Argument from Design, 348 ; on Good and Evil, 349 ; on Intuitive and Rational Actions, 391 ; on tendency of Evolutionist views, 348.
Hylonomus, 148.
 Ice-action in Permian, 168 ; in Post-pliocene, 270.
Ichthyosaurus, 213.
Iguanodon, 202.
 Insects, Devonian, 107 ; Carboniferous, 135.
 Intelligence of Animals, Nature of, 328.
 Jurassic, subdivisions of, 190.
 Kames, 286.
 Kaup on Dinotherium, 251.
 Kent's Cavern, 304.
 King-crabs of Carboniferous, 154.
 King on Carboniferous Reptiles, 143.
Labyrinthodon, 201.
Lalaps, 203.
 Lamb-shells, 40.
 Land-snails of Carboniferous, 138.
 La Place's Nebular Theory, 7.
 Laurentian Rocks, 18 ; Life in the, 23 ; Plants of the, 32.
Lepidodendron, 103, 106, 127.
Leptophleum, 104.
 Limestone Carboniferous, 96 ; Nummulitic, 241 ; Milioline, 245 ; Silurian, 64 ; Origin of, 27, 63, 89.
Limulus, 154.
Lingulæ, 39.
 Lingula Flags, 38.
 Logan, Sir W., on Laurentian Rocks, 18 ; on Reptilian Footprints, 143.
 London Clay, 247.
 Longmynd Rocks, 38, 47.
 Lower Helderberg Group, 62.
 Ludlow Group, 62.
 Lyell, Sir C., on Devonian Limestone, 89 ; on Wealden, 191 ; on Classification of the Tertiary, 238.
Machairodus, 250.
 Magnesian Limestones, 166.
 Mammals of the Mesozoic, 208 ; of the Eocene, 247 ; of the Miocene, 250 ; of the Pliocene, 256 ; of the Post-glacial, 300.
 Man, Advent of, 286.
 Man, Antiquity of, 292 ; History of, according to Theory of Creation, 377 ; according to Evolution, 381 ; widely different from Apes, 360 ; a new type, 365 ; Primitive, not a Savage, 367 ; his Spiritual Nature, 384, 370, 387 ; Locality of his Origin, 373 ; Primeval, according to Creation, 377 ; according to Evolution, 381.

- Mayhill Sandstone, 60.
 Medina Sandstone, 60.
Megalosaurus, 203.
 Menevian Formation, 38.
 Mesozoic Ages, 188; subdivisions of,
 189; Flora of, 199; Coal of, 201;
 Crustaceans of the, 225; Reptiles
 of the, 201, 212.
 Metalliferous Rocks, 167.
 Metamorphism, 21.
Microlestes, 208.
 Milioline Limestones, 243.
 Miller on Old Red Sandstone, 86.
 Millipedes, Fossil, 136.
 Miocene Plants, 260; Climate,
 264; Mammals of, 250.
 Mississippi, Delta of the, 296.
 Modern Period, 283.
Mosasaurus, 206.
 Mosse on Lingula, 39.

 Nebular Theory, 7.
 Neolithic Age, 284.
 Neozoic Ages, 286; divisions of,
 239.
 Newberry on Dinichthys, 99.
 Nicholson on Graptolites, 72.
 Nummulitic Limestones, 241.

Oldhamia, 45.
 Old Red Sandstone, 86.
 Oneida Cingluneral, 69.
Orthoceratites, 69, 154.
 Oscillations of Continents, 179.
 Owen on Dinosaurs, 202; on Mar-
 supials, 209.

 Palæolithic Age, 284, 289.
Palæophis, 245.
 Palæozoic Life, 181; diagram of,
 186.
 Paley on Design in Nature; his
 illustration of the watch, 349.
 Peat of Abbeville, 294.
 Pengelly on Kent's Hole, 304.
Pentremites, 153.
 Periods, Geological, 195, 175.
 Permian Age, 160; Geography of
 the, 163; Ice-action in the, 168;
 Plants of the, 172; Reptiles of
 the, 172.
 Phillips on Dawn of Life, 30; on
 Ceteosaurus, 204.

 Pictet on Post-pliocene Mammals,
 256; on Post-glacial Animals,
 357.
 Pictures of Primeval Man, 376.
 Pierce on Diminution of Earth's
 Rotation, 165.
 Pines of the Devonian, 105; of the
 Carboniferous, 131; of the Per-
 mian, 173.
 Placoid Fishes, 96.
 Plants of the Laurentia, 32; of the
 Silurian, 76; of the Devonian,
 102; of the Carboniferous, 124;
 of the Permian, 172; of the
 Mesozoic, 199; of the Tertiary
 258; classification of, 122.
 Plateaus, Continental, 57.
Plesiosaurus, 213.
 Pliocene, Climate of, 266; Mam-
 mals of, 256.
Pliosaurus, 215.
 Pluvial Period, 287.
 Post-glacial Age, 283, 292.
 Post-pliocene Period, 274; cold,
 278; Ice-action in the, 270;
 Subsidence, 279; Elevation, 284;
 Shells, evidence of, against Deri-
 vation, 358; Mammals, evidence
 of, against Derivation, 357.
 Potsdam Sandstone, 38.
 Prestwich on St. Acheul, 294.
 Primordial Age, 36; Crustaceans
 of the, 42.
Protichmites, 45.
Protorosaurus, 172.
Prototaxites, 76.
Psilophyton, 76, 103.
Pteraspis, 76.
Pterichthys, 98.
Pterodactyls, 206.
Pterygotus, 93.
Pupa Vetusta, 139.

 Quebec Group, 60.

 Rain-marks, 47.
 Ramsay on Permian, 168.
 Red Sandstones, their Origin, 110,
 166.
 Reptiles of the Carboniferous, 143;
 of the Permian, 172; of the Me-
 sozoic, 201, 212.

- Rhinoceros, Fossil, 300.
 Rocks, Colours of, 110.
 Rotation of the Earth, its Gradual Diminution, 165.
- Satter on Fossil Crustacea, 155.
 Sedgwick on Cambrian, 56, 75.
 Seeley on Pterodactyls, 206.
 Shrinkage-cracks, 47.
Sigillaria, 104, 124.
 Silurian Ages, 56; Cephalopods of the, 69; Corals of the, 63; Crinoids of the 68; Crustaceans of the, 71; Fishes of the, 74; Plants of the, 76.
 Siluro-Cambrian, use of the term, 56.
 Slaty Structure, 48.
 Solidity of the Earth, 6.
 Somme, R., Gravels of, 292.
 Species, Nature of the, 327; how Created, 352.
 Spencer, his Exposition of Evolution, 321, 331.
 Spiritual Nature of Man, 384, 370, 387.
 Spore-cases in Coals and Shales, 106.
 Stalagmite of Caves, 305.
 Striated Rock-surfaces, 269.
 Stumps, Fossil of, Carboniferous, 140.
 Synthetic Types, 181.
- Table of Devonian Rock, 85; of Palæozoic Ages, 187; of Mesozoic Ages, 234; of Neozoic Ages, 298; of Post-pliocene, 276.
- Temperature of Interior of the Earth, 4.
 Tertiary Period, 236; Mammals of, 247, 250, 256; classification of its Rocks, 238.
 Thomson, Sir W., on Solidity of the Earth, 6.
 Time, Geological Divisions of, 175.
 Tinière, Cave of, 293.
 Trenton Limestone, 59, 63.
 Trias, Divisions of, 189; Footprints in the, 203.
 Trilobites, 43, 94, 154; Feet of, 43.
 Turtles of Mesozoic, 218.
 Tylor on Pluvial Period, 287.
 Tyndall on Carbonic Acid in Atmosphere, 123.
- Uniformitarianism in Geology, 3.
 Utica Shale, 60.
- Volcanic Action, 7; of Cambrian Age, 36; of Silurian Age, 62; of Devonian Age, 81, 83.
 Von Dechen on Reptiles of Carboniferous, 143, 145.
 Von Meger on Dinosaurs, 202.
- Walchia*, 173.
 Wallace, his views on Inapplicability of Natural Selection to Man, 368.
 Wealden, 191.
 Wenlock Group, 62.
Williamsonia gigas, 200.
 Williamson on Calamites, 131.
 Woodward on Pterygotus, 93.
- Zaphrentis, 92.

HODDER & STOUGHTON'S
NEW AND RECENT PUBLICATIONS.

—o—o—o—o—o—
PROFESSOR STANLEY LEATHES.

The Structure of the Old Testament. In a Series of Popular Essays. By the Rev. STANLEY LEATHES, M.A., Professor of Hebrew at King's College, and Boyle Lecturer on "The Witness of St. John to Christ," &c.

E. DE PRESSENSÉ, D.D.

Heresy and Christian Doctrine. By E. DE PRESSENSÉ, D.D., Author of "Jesus Christ, His Times, Life, and Work," &c. Forming a Third volume of "The Early Years of Christianity." In 8vo, 12s., cloth.

A POSTHUMOUS WORK BY DEAN ALFORD.

Sons of God: the Known and the Unknown. Being Sermons preached in Canterbury Cathedral on Sunday afternoons preceding and during Advent. By the late HENRY ALFORD, D.D., Dean of Canterbury. Second Thousand, fcap. 8vo, 3s. 6d., cloth extra.

THE AUTHOR OF "CUES FROM ALL QUARTERS."

Aspects of Authorship; or, Book Marks and Book Makers. By FRANCIS JACOX, B.A., Cantab., Author of "Cues from all Quarters," "Secular Annotations," "Bible Music," &c. In crown 8vo, 8s. 6d., cloth.

"An interesting book. The compiler has brought together with great and long-continued industry a multitude of facts respecting books, the writers of books, where they wrote, why they wrote, how their works were received, and many others. He has produced a very readable book, one that the reader may dip into on any page, sure of finding something to interest him. What strikes one most is the number of incidents here got together, an evidence of wide reading in several modern languages."—*Literary Churchman.*

REV. SAMUEL COX, OF NOTTINGHAM.

An Expositor's Note Book ; or, Brief

Essays on Obscure or Misread Scriptures. By SAMUEL COX,
Author of "The Resurrection," "The Private Letters of St. Paul
and St. John," &c. Crown 8vo, 8s. 6d.

"A series of short essays of which it is difficult to exaggerate either the value or importance. The author has brought to his task so much learning, devoutness, research, and care, that what he terms brief essays will meet with wide and ready acceptance. He has selected from the sacred volume such passages as seemed to him obscure or otherwise hard to interpret, and deals with these difficulties in the wise, calm, and impartial spirit, not only becoming his theme, but certain to teach and to convince all who are in search of truth. The chapters are thirty-one in number, but they touch upon, illustrate, and explain a far larger number of texts ; and among them all there is not one unworthy of diligent perusal. We augur for the "Expositor's Note Book" a wide and lasting popularity."—*Standard*.

"Mr. Cox is already well-known as one of the ablest and most accomplished of living expositors of Scripture. In these thirty-one essays we have the golden fruit of the learned research and keen thinking of thirty years. They are full of suggestive and beautiful thought."—*Congregationalist*.

DR. ALEXANDER MACLEOD, OF BIRKENHEAD.

Talking to the Children. By ALEXANDER MAC-

LEOD, D.D. Third edition, price 3s. 6d., handsomely bound.

CONTENTS :—At the Parting of the Ways.—The Three Temptations.—The Wonderful Lamp.—Paths the Lamp Shines on.—The Story-Tellers and the Lamp.—In the Valley of the Shadow.—How Christ Dries up our Tears.—Children of Light.—More about Children of Light.—The Bird and the King.—The Door of the Heart.—Christ Knocking.—The Mouse-ear.—The Mouse-ear in the Garden.—The Battle of Life.—William and the Lie.—St. George and the Dragon.—Charlie's Feat.—Why Children should be glad for Christ.—The Palace of Life,

"A series of admirable addresses on religious subjects, abounding with anecdote and narrative, and expressed with a happy art of strong simplicity. It is enough to say of it that it is the talk of a strong wise man."—*British Quarterly Review*.

THE AUTHOR OF 'REDLANDS.'

Una ; or, The Early Marriage. By HAR-

RIETTE BOWRA, Author of "Redlands." In one volume, crown
8vo, 7s. 6d.

"A really readable novel, without too much of the 'goody' element, which may safely be placed in the hands of all young girls. The authoress has a clear vivid style of her own which carries us along and never allows our attention to flag."—*Westminster Review*.

New and Recent Publications.

JAMES BONWICK, ESQ., F.R.G.S.

The Mormons and the Silver Mines. By

JAMES BONWICK, F.R.G.S., Author of "Last of the Tasmanians,"
&c., &c. Crown 8vo, 7s. 6d., cloth. [Just Published.]

CONTENTS:—1. The Mormon Home.—2. Religion of the Mormons.—3. Polygamy at Utah.—4. My Mormon Fellow-Traveller.—5. Mormon Nonconformists.—6. The Mormon Press.—7. Signs of Change in Mormonism.—8. The Political Situation.—9. Education in the Far West.—10. Woman's Rights in America.—11. Silver Mines.—12. The Labour Question at the Mines.—XIII. My American Travelling Companions.

"His volume is a very interesting one, and it is particularly so because it shows that the practice of polygamy is rapidly dying out, and that the religious system of Mormonism is dying out. The author writes very graphically, and any one desiring a good account of the Mormons as they exist at present cannot do better than study his book."—*Court Circular.*

THE CHRISTIAN EVIDENCE SOCIETY'S LECTURES.

Faith and Free Thought: Being a Second

Course of Lectures delivered at the request of the Christian Evidence Society. With a Preface by the Right Rev. SAMUEL WILBERFORCE, D.D., Lord Bishop of Winchester. Second Thousand. Crown 8vo, 7s. 6d. cloth.

CONTENTS:—1. The Principles of Causation Considered in Opposition to Atheistic Theories. By Rev. J. B. MOZELY, D.D., Canon of Christ Church, and Regius Professor of Divinity, Oxford.—2. The Evidence Afforded by the Order and Adaptations in Nature to the Existence of a God. By CHARLES BROOKE, Esq., M.A., F.R.A.S.—3. The Philosophy of Human Responsibility. By the Rev. Canon BIRKS, M.A., Professor of Moral Philosophy, Cambridge.—4. Points of Supposed Collision between the Scriptures and Natural Science. By J. H. GLADSTONE, Ph. D., F.R.S.—5. The Alleged Moral Difficulties of the Old Testament. By the Rev. THOMAS POWNALL BOULTBEE, LL.D., Principal of St. John's Hall, Highbury.—6. On the Corroborative Evidence of Old Testament History from the Egyptian and Assyrian Monuments. By W. R. COOPER, Esq., Secretary of the Society of Biblical Archaeology.—7. The Argument for the Supernatural Character of Christianity from its Existence and Achievements. By Rev. HENRY ALLON, D.D.—8. Christianity Suited to all Forms of Civilization. By Sir BARTLE FRERE, G.C.S.I., K.C.B., D.C.L.—9. The Contrast between Pagan and Christian Society. By the Very Rev. CHARLES MERIVALE, D.D., Dean of Ely.—10. The Force imparted to the Evidence of Christianity from the Manner in which a number of Distinct Lines of Proof converge in a Common Centre. By BENJAMIN SHAW, Esq., M.A., late Fellow of Trinity College, Cambridge.—11. Man a Witness for Christianity. By Rev. JOSEPH ANGUS, M.A., D.D.

Modern Septicism. A Course of Lectures delivered at the request of the Christian Evidence Society. With an Explanatory Paper by C. J. ELLICOTT, D.D., Lord Bishop of Gloucester and Bristol. Seventh Edition. In crown 8vo, 7s. 6d., cloth.

PROFESSOR REUSS, OF STRASBOURG.

History of Christian Theology in the Apostolic Age. By EDWARD REUSS, Professor in the Theological Faculty, and in the Protestant Seminary of Strasbourg. Translated from the Third German Edition, by ANNIE HARWOOD. With Preface and Notes by R. W. DALE, M.A. Vol. I., 8vo, cloth, price 12s.

"Extensive and exact scholarship, a discriminating and sober judgment, a reverent feeling, and a pure historical spirit, combine to make M. Reuss one of the foremost of the few *exegetes* that French Protestantism possesses."—*British Quarterly Review*.

Scripture and Nature; the Analogy between Horticulture and the Divine Human Culture. In crown 8vo, price 6s.

"This is a remarkable, instructive, and suggestive book."—*Family Treasury*.

"I like the book very much; the thought and reasoning are all that could be wished. I look upon it as a very valuable monograph of the correspondences between the natural and the spiritual, throwing clear and beautiful light especially upon the analogies between the natural process of grafting and the conversion and regeneration of the human soul."—*Rev. Hugh Macmillan, LL.D*

Science and Humanity; or, A Plea for the Superiority of Spirit over Matter. By NOAH PORTER, D.D., LL.D., President of Yale College. Crown 8vo, 2s. 6d., cloth.

"This brief, admirable, and thoughtful essay reveals at every turn the extensive acquaintance of the author with every phase of philosophic inquiry."—*British Quarterly Review*.

"Dr. Porter is well known in America as an able writer, and the volume before us will add considerably to his reputation, and further the good cause of revealed religion."—*Standard*.

The Credibility of the Christian Religion; or, Thoughts on Modern Rationalism. By SAMUEL SMITH. New Edition, Fifth Thousand. Price 1s. 6d., cloth.

"It is singularly clear and felicitous in reasoning, apposite and attractive in illustration, simple and forcible in language, and it strikes upon the spirit with the true power of a felt Christian faith. It contains much that is valuable to an inquiring mind, much that concerns those who have to do with the inquiring, and a great deal that will fascinate and improve those who delight in excellent argument excellently put."—*British Controversialist*.

"His lectures are in all respects admirable, intelligent, clear, and convincing."—*Evangelical Magazine*.

"Though popular in its style, it grapples none the less ably and intelligently with many of the difficulties which are presented on every side at the present day. The writer has a great grasp on every subject he handles, and is also most extensively read. His vindication of the Bible, of miracles, and of leading doctrines is one of the ablest we have read."—*Christian Work*.

LONDON: HODDER & STOUGHTON, 27, PATERNOSTER ROW.