Report on the geology of South Carolina

Tuomey, M.

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Chapter IV.

The characteristic plants are the coniferæ, related to Cycas and Zamia. The ferns have diminished in numbers, and Calamites and kindred genera have nearly disappeared. Such a Flora is found at the Cape of Good Hope and near the coast of New Holland.

The third epoch is distinguished by the prevalence of Dicotyledonous plants of existing genera. A few Cycadeæ and ferns occur, together with the remains of palms; the whole group, indicating a climate a little warmer than that of the Southern United States, where the palms are represented by the palmetto and sabal, which are found growing with the ash, elm, willow and cypress. Such is the Flora of the Tertiary period.

The following table* shows the number and distribution of fossil plants, according to the recent researches of M. Goppert. In 1836 only 527 fossil plants were known; at present the number amounts to 1792, which shows the rapid progress made in this department of Palæontology.

Of living plants there are known to Botanists 80,000 species; of these a large number are Fungi and Fucoids, which, on account of their destructible nature, could rarely occur in the fossil state—so that the proportion of fossil to recent plants is quite large.

Middle and older Palæozoic rocks	52
Carboniferous	819
Permian	58
Triassic	86
Oolite	234
Wealden	16
Cretaceous	62
Tertiary	454
Unknown	11
	1792

CHAPTER IV.

Fossilliferous Rocks.—Classification.—Palæozoic Series.—Lower Silurian.—Upper Silurian.—Old Red.—Carboniferous System.—Coal Measures.—Secondary Period.—New Red.—Lias.—Oolite.—Wealden Formation.—Cretaceous System.—Tertiary Period.—Eocene.—Miocene.—Pliocene.—Post Pliocene.—Succession of Organic Remains.—Mosaic Account of Creation.

We have next to consider an exceedingly interesting class of rocks, comprehending a large series of formations, composed of sedimentary deposits, called fossilliferous from the fact that they contain organic remains—an evidence that they were formed since the appearance of life on the

*Brit. Ass. Reports.

earth. The oldest of these formations pass, by insensible gradations, into the metamorphic rocks, from which they can only be distinguished, as I have already remarked, by the presence of fossil remains. In mineral character they are generally less chrystalline, and the comparative abundance of carbonate of lime also serves, in some measure, to distinguish them from the metamorphic rocks. As we ascend in the scale the lime increases, the strata become less consolidated, until we reach the beds of loose sand, clay, &c. that characterise the deposits now in process of formation.

The earliest classification of these rocks consisted of a division into three great groups or systems, designated the Transition, Secondary, and Tertiary Systems. The Transition rocks included those that were deposited during that period in which the earth was supposed to be in a state of passage from an uninhabitable to a habitable state, and these rocks consequently contain the remains of the earliest inhabitants of the globe.

The rocks of the Secondary period give evidence of a second great change in the physical condition of our planet, which affected, in a remarkable degree, the character of its Fauna and Flora.

And the fossils entombed in the rocks of the Tertiary present a nearer approach to the living forms of the present period.

More extended investigations have shown each of these great divisions to contain many groups quite distinct and well characterised. The distinctive characters of these groups are derived from the combined evidence of superposition, mineral contents, and organic remains, but principally from the latter.

TABLE,

Showing the order of superposition of the Fossiliferous Rocks.

RECENT PERIOD, OR POST PLIOCENE.		
Systems, Formations, and Groups.	Localities of characteristic deposits in America.	European Equivalents and Localities.
Alluvium, *Stratified beds of clay and sand*, containing the remains of extinct mammals and recent shells. Drift, or Diluvium.	Superficial deposits. Northern States. Atlantic coast.	Found in all countries. Northern Europe.
TERTIARY PERIOD.		
Newer Tertiary, or Pliocene.	South Carolina.	Till of the Clyde valley, Norwich crag. Subapennine beds.
Middle Tertiary, or Miocene.	Maryland, Virginia, North Carolina.	Red crag, Basin of the Rhine, Molasse of Switzerland.
Older Tertiary, or Eocene.	Maryland, Virginia, South Carolina, Alabama.	London clay, Paris Basin, Auvergne.

Systems, Formations, and Groups.	Localities of characteristic deposits in America.	European Equivalents and Localities.
NEWER SECONDARY PERIOD.		
Cretaceous System.		
Upper chalk, (with flints)		Maestricht beds.
Lower chalk, (without flints.)		
Chalk Marl.		Craie tufau.
Upper Greensand.	New Jersey.	
Gault.	South Carolina.	
Lower Greensand.	Alabama.	Neocomien.
MIDDLE SECONDARY PERIOD.		
Wealden Formation.		
Weald clay.		Portland.
Purbeck beds.		Surrey, Kent & Sussex.
Oolite System.		
Portland stone.		Oxford, Bath.
Kimmeridge clay.		Jura chain.
Forest marble.		
Great Oolite.		
Inferior Oolite.	Virginia ?	
Lias Group.		
Upper Lias.		Lyme regis.
Lower Lias limestone.		Whitby.
OLDER SECONDARY PERIOD.		
Upper New Red, or Triassic System.		Keuper.
Saliferous, or New Red Sandstone.	Massachusetts.	Muschelkalk.
	Connecticut.	Bunter sandstone.
Red Sandstones and Conglomerates.	Virginia.	(Gres bigarre.)
	N. and S. Carolina.	
NEWER PALÆOZOIC PERIOD.		
Magnesian Limestone, or Permian System.		Permia, Russia, Zechstein.
Magnesian Limestone.		
Lower New Red.		Rothe-todte-liegende.
Carboniferous System.		
Coal Measures.	Pennsylvania.	Coal Measures of the North of England.
Millstone grit.	Virginia.	
Carboniferous, or Mountain Limestone.	Ohio.	
	Alabama.	
Lower Carboniferous Shales.		
MIDDLE PALÆOZOIC PERIOD.		
Devonian System, or Old Red Sandstone.	New York.	
Yellow quartzose sandstone.	Pennsylvania.	Devonshire.
Flagstones.	Ohio.	
Limestones.	Michigan.	
Conglomerates.		

OLDER PALÆOZOIC PERIOD.

New York System.

Systems, Formations, and Groups.	Localities of characteristic deposits in America.	European Equivalents and Localities.
Upper Silurian Rocks.		
Chemung Group.		
Genesee Slate.	New York and Western States.	Wales.
Marcellus Slate.		
Ludlow and Wenlock Series.	Alabama.	Russia.
Hilderberg Series.		
Lower Silurian Rocks.		
Caradoc Sandstone.		
Llandeilo Flags.	Vermont.	Wales.
Champlain Division.	New York.	Scandinavia.

Palæozoic Series.

Pursuing the ascending order which has been adopted in this outline, we have next to take a rapid glance at the succession of the fossiliferous strata, beginning with the Palæozoic Series, which consists of the Silurian System, the Devonian, or Old Red Sandstone System, the Carboniferous System, and the Magnesian Limestone, or Permian System.

Lower Silurian Strata.—The term Silurian, (from *Silures,* the name of the ancient Britons, who inhabited Wales, where these rocks are extensively developed,) was first applied by Mr. Murchison, to designate the oldest of the fossiliferous rocks. Local names are useful, because they point to localities that can always be examined when any doubt arises as to the meaning of the author; for such names are taken from places where the rocks to which the names are applied occur in their most characteristic form. Hence, in England, the names Caradoc sandstone and Llandeilo flags, and in this country, Trenton limestone, Potsdam sandstone, &c. applied to the Lower Palæozoic rocks.

The Lower Silurian rocks, for the most part, consist of sandstones, conglomerates, impure limestones, and shales. Argillaceous and silicious matter is far more abundant than in the newer rocks, and the presence of mica proves that they owe their origin to the disintegration and abrasion of the granitic or the metamorphic rocks.

In New York, where these rocks are finely developed, and where they have been studied with great care, they are known under the names of Potsdam sandstone, Birdseye limestone, Trenton Limestone, Utica slate, Hudson River group, &c. The principal of these formations extend along the Alleghanies, from New York to Alabama. Commencing at Vermont, they appear at intervals on the shores of the lakes, to the Mississippi River; and they are also found both in Ohio and Tennessee. They are seen again in the Southern part of South America. In England, as well as on the Continent, these strata are widely spread. They are well known in Germany, and have been traced over a considerable extent in Russia, by Mr. Murchison. They occur in Norway and Sweden of vast thickness, and in Southern Africa they have also been recognized.

In America the oldest of the Silurian rocks are represented by the Potsdam sandstone of the

New York Reports, and it is remarkable that the first appearance of life on our continent, as presented in this rock, occurs in the form of the shell of a marine animal, the *Lingula*, a genus of which there are a few species living at the present day—a fossil which is also found in great abundance in Russia. Fucoids, or sea-weeds, are generally the first organic remains found in these rocks; and in Norway and Sweden, according to the researches of Prof. Forchammer, they have played quite an important part in the formation of the oldest fossiliferous strata. As we ascend in the series fossils become more abundant: in the Trenton limestone there are more than twenty genera.

The Hudson River group Mr. Hall considers the true equivalent of the Cambrian system of Great Britain. It marks, in the New York system, a very important point, for scarcely any fossil species are common to it and the superincumbent rocks in that State.

The chief characteristic of the Fauna of the lower Silurian rocks is the great development of Brachiopod molluscs of the genera Terebratula, Orthis, Delthyris, Atrypa, &c. and a remarkable family of Crustaceans, the Trilobites, now extinct. It is supposed these ancient articulated animals stood in the same relation to the fucoidal plants of the Silurian seas that the numerous small crustacea of the present day do to the sea-weeds, among which they abound. Some corals and other remains are also found among these early inhabitants of the globe. They exhibit, however, as a group, animals of low organization—not extending higher in the scale of being than the class Articulata. And no vestige of land plants or of any vertebrate animal has yet been discovered in these rocks.

Upper Silurian Rocks.—In America this division of the Palæozoic series is represented by the formations between the Niagara group and the Chemung group of the New York Reports; and by formations Nos. 7, 8, and 9 of the Pennsylvania and Virginia Surveys; in Ohio, by the Cliff limestone and Waverly sandstone; and in Michigan, by the Mackinac limestone, and the sandstones of Point aux Barques.

In England they include the rocks known as the Ludlow and Wenlock formations, which consist of beds of great thickness of shales and limestones. On the continent of Europe they have been traced at intervals from Norway to Constantinople. They are found in South America and in the Polynesian Islands.

These rocks abound in Trilobites, Crinoidea, and a peculiar chambered shell, called Orthocera. In the upper, or Wenlock, formation scales and teeth of fishes, and an ichthyodorulite, (a part of the fin of a fish,) have been found in the coniferous limestone of the New York system. These are the sole remains yet found of vertebrate animals in the Silurian rocks of this country.

Land plants, such as ferns, make their appearance towards the uppermost groups of the series. The rocks of the New York system resemble the Silurian rocks of Russia, in reposing horizontally and without disturbance on the metamorphic rocks.

The absence of any disturbing cause for so long a period is remarkable. The Silurian system, as developed in New York, presents the enormous thickness of eight or nine thousand feet, and in England these rocks are equally extensive. The organic remains found entombed in them on the spot where the animals to which they belonged lived and died, show that they were deposited gradually and slowly. So that the period of time necessary for the deposition of so great a mass of sedimentary matter must be immense.

Devonian or Old Red Sandstone System.—The rocks of this system consist of slates, limestones, conglomerates, and sandstones, of a brick-red colour. In New York this system is best developed in the Cattskill group, where it rises into mountain peaks. In Pennsylvania and Virginia it is seen dipping under the conglomerates of the carboniferous system, but thins out towards the West. In Michigan it occupies a considerable space, and is found underlying the coal measures in the Western States.

In England this system is well developed, and until a comparatively recent date it was thought to be a local deposit confined to that country. In Westmoreland and Herefordshire the Silurian rocks are seen passing into the Devonian rocks. In Scotland the system appears resting upon gneiss, the lower beds consisting of conglomerates of enormous thickness. It is here that these rocks have been studied with greatest care—a ground rendered classic by the genius of Miller.

The Old Red Sandstone system of Russia bears a strong analogy to the English rocks of the same age, and many of the fossil shells are common to both. Previous to the study and correct determination of the British rocks, much difficulty was experienced in referring the Devonian system of Belgium and other parts of Europe to its place in the series; but its true position in England once settled, its peculiar fossils rendered the task less difficult elsewhere. The thickness of these rocks in America is at least ten thousand feet, but in Europe it is far greater.

Corals were quite abundant during the period of the formation of the Old Red, and the molluscs number some genera of higher organization than any that preceded them. The genus Clymenia seems to connect the Nautilus and Ammonite. On the other hand, the Trilobites, which were so abundant in the Silurian system, have disappeared so rapidly as to become quite rare. It is the remains of fishes, however, that afford the most striking characteristic of the system. Some of these Placoids, a family of cartilaginous fishes, the rest Ganoids. Some of them so singular and so unlike all the known forms of these animals as to require the genius of Agassiz for their determination and distribution in their proper place in the scale of creation. One of the most remarkable of these, the Cephalaspis, strangely reminds one of the common Limulus or King Crab, of our coast. The Pterichthys and Coccosteus were covered with beautiful and regular plates, forming a scaly armour of great strength. The Holoptychius was another of those strange fishes, found in the Old Red sandstone of Scotland, differing as much from all the rest as they did from the forms of the present day. Of fishes of this latter genus, Mr. Hall has figured the scales and a tooth in the Geological Report of the Fourth District. He has also figured, in the same Report, some bones, which he supposes the remains of a Saurian—the first of the type known in this system.

Carboniferous System.—This system is composed of strata of limestone, of great thickness, called *Mountain Limestone*, and an immense group of rocks, composed of shale, coal, and sandstone, which are found resting upon beds of conglomerates, and a white or gray sandstone, called mill-stone grit. The mountain limestone, which is found at the base of the system, is very generally, in this country, interstratified with beds of hornstone and cherty limestone; towards the top a stratum of magnesian limestone is found, and another bed of the same rock occurs near the base of the group, on the southern flank of the Cumberland Mountains. Prof. Troost has shown that the uppermost beds pass into an Oolite rock, on the mountains just named, and in St. Clair County, Alabama, similar beds occur, that are entirely silicious. The mountain limestone is extensively developed in the United States, being every where found underlying the coal measures. Dr. Troost estimates its thickness on the sides of the Cumberland Mountains at 200 feet, but near

Huntsville, Ala. some little mounts occur, composed almost entirely of this rock, which Dr. Newman informed me are 1000 feet high. In general it assumes its greatest thickness towards the South. It is in this rock that the great caves of the West are found.

Two characteristic fossil corals are abundant in this formation, *Stylina Perroni* and the *Archimides of Lesueur*. Besides these, innumerable crinoideans of the genus *Pentremites* are found studding the weathered surface of the rocks.

Next above this limestone we have beds of sandstone and conglomerate, that in the Western and South-western States vary from 50 to 200 feet in thickness. The beds furnish mill-stones in every country where they occur, and hence the name mill-stone grit, by which they are every where known. The sandstone is also equally noted for furnishing good fire-proof stone for iron furnaces and similar purposes.

Resting immediately upon these, we find the *Coal Measures*, which consist of beds of shale, clay, coal, and sandstone, and from which this system derives its name and importance. The coal is found in seams, alternating with beds of shale and sandstone, and varying in thickness from an inch to many yards.

In some of the English coal-fields the number of these seams amounts to seventy-five, making a total thickness of 150 feet of coal.

The great coal-field on the West of the Alleghany Mountains, extending from Pennsylvania to Alabama, must be 800 miles long and 200 miles wide at its greatest width. While the coal-field of Illinois must equal (Dr. Owen) in extent the whole of England. There are from six to ten seams of coal in these coal fields.

Although coal is found enclosed between beds of sandstone, in general it is found resting on beds of clay, called under-clay, which is more or less mixed with carbonaceous matter, and containing Stigmariæ, with rootlets extending in all directions through the clay. The coal presents a jointed structure, which causes it to break into prismatic fragments. The upper surface of the coal is often covered with vegetable impressions and even charcoal. The shale which overlies the coal is laminated, and between the laminæ impressions of ferns are found in great abundance and in fine preservation. Both in the shale and overlying sandstones fossils of the genera *Sigillaria*, *Stigmaria*, Calamites, and Lepidodendron, are quite common.

It is now universally admitted that coal is of vegetable origin—wood, &c. carbonized under great pressure. Whenever the carbonization of the vegetable matter took place under circumstances that prevented the escape of the gases the result is bituminous coal, but where they were allowed to escape, anthracite is produced. We have abundant proof of this wherever the coal measures are much fractured—as, for instance, along the anticlinal axis of the Alleghany Mountains, where the anthracite of Pennsylvania occurs, and in the New Red sandstone of North Carolina, where the bituminous coal is converted into anthracite in the vicinity of the trap dykes, by which it is intersected.

The structure of wood may be detected in coal by the aid of the microscope, and it appears that coniferous trees formed no inconsiderable portion of the mass. Drifted wood, accumulating in estuaries and at the bottom of seas of limited extent, has been proposed to account for the carbonaceous matter of coal; but the perfect state in which fossil plants of the most delicate structure are preserved in the overlying shale, seems, in most cases at least, to forbid this, for it is difficult to suppose that they could have been removed from the spot where they grew, without having their forms entirely destroyed.

That the greater portion of the coal plants lived and died where we find them, there can be no doubt. Many of our swamps present such a state of things as may be supposed to have existed in those ancient coal-fields while their plants were yet growing. We have a depth of vegetable matter, often amounting to 20 or 30 feet, composed of the trunks of fallen trees, roots, and leaves, in all stages of decay; and upon this a dense growth of ferns, reeds, vines, and other luxuriant plants that love shade and moisture. These swamps are sometimes partially submerged by the muddy water of our rivers during freshets; a deposit of mud is often left, which is quite sufficient to show us how the most delicate plants may be enclosed, and their impressions preserved with great accuracy. If a subsidence of the whole be now supposed to take place, so as to allow of its being overflowed by the waters of the sea, it would, in time, be covered by sedimentary matter, which would enclose marine shells and fishes, such as we find in the sandstones of the coal measures. Heat applied below, under these circumstances, would char the vegetable matter and convert it into coal.

So far this hypothesis is plain; and very rationally accounts for the formation of *one* bed of coal, but where there are several beds, one above the other, we are obliged to suppose the elevation of the submerged coal-field sufficiently above the water to allow of another and a similar accumulation of vegetable matter: subsidence must again take place, and this matter be converted into coal. This alternate subsidence and elevation must be repeated for every seam of coal present in a coal-field. The difficulty is to account for this repeated, and often apparently regular oscillation of the earth's surface.

The basin shaped depressions in which coal is found, is remarkable, but is far from being universal, and is probably accidental, and not necessarily connected with the formation of coal. The long trough-like coal-fields of Alabama are the result of the elevatory forces that upturned the edges of the underlying Silurian rocks.

The Flora of the Carboniferous System is characteristic of a damp, warm climate, such as at present is peculiar to the islands within the tropics, for the luxuriant tree ferns of the coal formation have no representatives elsewhere.

Speculations upon the causes that have reduced such a climate to that of the present period, would lead us beyond the limits of a mere outline. Mr. Lyell,* who has treated this subject with his usual distinguished ability, attributes these changes of climate to an alteration in the relative distribution of land and water. The milder climate of insular, compared with main land, in the same latitude, is well known; and there can be no doubt that groups of islands such as marked the carboniferous period, would have the temperature of their atmosphere, and consequently their climate, greatly altered by being converted into continents. But it may be doubted that such a cause is alone sufficient to account for the extent of the changes of temperature that have taken place in past periods.

As may be inferred from what has been already said, the characteristic feature of the organic remains of this system, consist in the vast number of fossil plants, which amounts to one half of all the known species.

* Principles of Geology.

Corals of various genera and species abound in the calcareous strata, and even compose entire beds. And Crinoideans were scarcely less numerous. Of Brachiopodous molluscs the genus Productus seems to be most abundant. As a group the fossil molluscs resemble those of the existing seas, far more than any that preceded them. The fishes of the period included Ganoids of huge size, of which the Megalichthys was one of the most extraordinary.

Magnesian Limestone.—This formation is also known as the *Permian* system, from Permia, in Russia, where it is extensively developed. It rests upon the coal measures, or in depressions in the carboniferous limestone. In England it is included as an upper member in the *Lower New Red.* In Germany, where it forms a more important rock, it is known under the name of Zechstein, and the lower beds, which correspond with the Lower New Red of England, are called *rothe-todte-liegende.* It is not known to occur in the United States.

The fossils are not numerous, with the exception of fishes, of which there are some remarkable and characteristic genera. In England the first appearance of reptiles is observed in these rocks.

Secondary Period.

Upper New Red, or Triassic System.—This system is known in England, but, like the preceding, it is more extensive on the Continent, where the upper portion is known under the name of *Keuper.* This is separated from the lower beds by a band of limestone called by the Germans *Muschelkalk.* The lower part of the system is called grès bigarré.

In the United States the New Red occupies a portion of the valley of the Connecticut River, and extends through Connecticut and Massachusetts. It is found again in New Jersey, and extends through Pennsylvania, Maryland, Virginia, North Carolina, and terminates on Clay Creek, in Chesterfield District, South Carolina.

It is very uniform in mineral character, being composed of a brick-red sandstone. It is intersected through its entire extent by trap dykes.

The organic remains found are few—the most important, if we except the bird tracks, being the Ganoid fishes, discovered in the Connecticut valley. True heterocircal fishes are lost in the formations above this.

In North Carolina some beds of coal of workable thickness are found in this system, on Deep River. The beautiful *encrinites moniliformis* and *ammonites nodosus* are characteristic fossils of this system, in Europe. Reptilian footprints occur in England, and the remains of *Rhynchosaurus* and *Labyrinthodon* belong to the New Red.

The bird tracks of Connecticut show very conclusively that birds existed during the deposition of these rocks. Some of these foot-prints were of enormous size, as mentioned in the preceding pages; and the bird to which they belonged must have been capable of a stride six feet in length. It seems that there yet exist some doubts in the minds of English Geologists, as to the age of the Connecticut Red Sandstone.

Lias.—This and the succeeding group are included by the Geologists of Continental Europe, under the name of the *Jurassic System.* The rocks of the Lias are composed of beds of shaly and argillaceous limestones, marl and clay.

Of European rocks this group may be considered as among the most interesting to the Palæontologist, whether we consider the number and beauty of its fossils, or the strange and anomalous forms found among them. It is here that those huge and extraordinary Enaliosaurians, the Ichthyosaur and Plesiosaur, first make their appearance on the stage of their existence.

The Pentacrinite is found here in great abundance, as well as the *Belemnite* and *Ammonite.* The genus Gryphæa is so abundant in some of the strata as to give the name Gryphite limestone to certain beds of the group.

Gryphæa incurva is a characteristic species.

Oolitic System.—The Lias passes gradually into the overlying Oolitic beds. In England, where this system has been studied with most care, it has been divided into three well marked groups—the upper, middle and lower Oolite. The latter is represented by the "Bath Oolite," "Bradford Clay," and "Cornbrash;" the middle by the "Oxford Clay;" and the upper by the "Kimmeridge Clay." The Portland stone also belongs to the upper group of the system, as well as the noted "Dirt bed," which is composed of a bed of earth containing stumps of trees in the position in which they grew.

Like the preceding, the fossils of this group are numerous and interesting. The fossil plants consist of coniferous plants, together with characteristic species of Zamia and Cycas.

The Echinodermata are numerous both in genera and species. Encrinites are also found.—Insects also occur in this system—a fact indicative of the proximity of the shore to the spot where they are found.

In portions of these rocks the Cephalapoda are exceedingly numerous, whilst they are almost wanting in other parts. Reptiles of the orders *Crocodilia* and *Dinosauria* are found throughout the system, and the latter order is represented by the gigantic *Megalosaurus.*

The *Pterodactyle* was one of the strange organisms that marked this period; and what is still more interesting, the first mammal is found here. It is curious enough that no other traces of mammalian existence should be found till we reach the Tertiary period.

With the exception of the coal-beds of Eastern Virginia, no Oolite has been yet discovered in the United States. These beds have been referred to the lower Oolite by Prof. Rogers, and recent examinations of the organic remains of these beds, made in England by Mr. Lyell and others, seem to confirm this determination. It is, at all events, almost certain that they cannot be of greater age than the Lias.

Wealden Group.—This is an interesting deposit that overlies the Oolite in England. It is composed, for the most part, of beds of sand, clay, and gravel, supposed to be brought down by a river. The most remarkable animals of its Fauna were the gigantic herbivorous reptiles. The Iguanodon, discovered here by Dr. Mantel, must have been twenty-eight feet in length, and supported upon the most extraordinary legs, the femurs of which equal in size those of the elephant. Remains of fishes occur here, and fragments of the bones of Pterodactyle are also found. The Mollusca are confined to fresh water species, and a minute Crustacean, also an inhabitant of fresh water, is sufficiently abundant to form entire beds. The whole group is well characterized as a fresh water formation.

Cretaceous Group.—Next in order we have the very remarkable rocks which include the chalk of Europe, from which the formation derives its name. English Geologists have divided this group into three parts. The upper includes the Maestricht beds, and the chalk; to the middle belong the Upper greensand and Gault; and in the lower is placed the Lower greensand.

In Switzerland the lower division is represented by the *Neocomien* formation, which is found near Neufchatel.

In the United States the Cretaceous group is well represented along the coast of the Atlantic States, beginning at New Jersey. It is found in North Carolina, and it is exposed on the banks of the rivers in the Eastern part of South Carolina.

Mr. Lyell, who had examined these beds nearly throughout their entire extent, refers them to that part of the formation included between the Maestricht beds and the Gault inclusive. In this country the formation is every where characterised by Belemnites Americana, Exogyra Costata, Gryphæa Mutabilis, and two or three species of Ammonites. In Alabama a very large species of Hippurites occurs, which is often a foot in diameter.

The most remarkable reptile is the Mososaurus, a genus common to this continent and that of Europe.

The Ammonitidæ, after existing here in vast numbers, disappear forever. It is remarkable that the beds of chalk that every where characterize this formation in Europe should be entirely absent in America. In some of the New Jersey beds calcareous matter is abundant, but in North and South Carolina it forms not more than 25 or 30 per cent. of the mass, and in Alabama the formation becomes again highly calcareous.

Tertiary Period.

The Tertiary rocks are every where very variable in mineral composition and state of aggregation. Loose sands, gravel, clay, limestones and marl, are the principal materials which make up these rocks. Although widely distributed, they are not often found in continuous strata, but filling depressions in the underlying rocks. For a long time much confusion existed in relation to the relative age of the numerous formations comprised in the Tertiary period. The opening of the beds of the Paris basin, and the investigation by Brogniart and Cuvier of the organic remains brought to light, directed attention to this interesting field of enquiry. Tertiary fossils were collected, studied with care, and compared with living types; it soon became evident that many of the fossils were identical with living species. Of 1122 species of fossil shells, found in the Paris basin, 38 were identified with living forms by M. Deshayes, who first suggested that the Tertiary formations may be divided according to the relative proportion of extinct and living fossil shells which they may contain.

But it is to Mr. Lyell that we are indebted for a classification founded on this principle. At the time that this classification was proposed there were known from the Paris basin and other contemporaneous beds 1234 shells, of which 42, or about three and a half per cent. were living species. To such beds Mr. Lyell has given the name "Eocene," which implies the dawn of the present state of things on the earth; for it is here that we find the first species that has a living representative; besides, the whole group resembles those now inhabiting our seas.

In other deposits Mr. Lyell found that the proportion of living to extinct species amounted to seventeen per cent. These beds he designated as "Miocene"—"less recent," from the small number of recent species found in this formation. Of 1021 species examined, only 176 are living.

The next division consisted of those beds in which the recent species were present in great number, compared with the Miocene formation, and was therefore named "Pliocene"—"more recent." This formation was again sub-divided into older and newer Pliocene.

In the newer Pliocene, out of 226 fossils, 216 were found to be of living species, and in the older Pliocene, of 569 species, 238 were found to be of recent species. In general the proportion is found to be about one half.

Mr. Lyell estimates the number of species common to the Miocene and Pliocene at 196, of which 114 are living, and 82 are extinct.

In this country the terms upper, middle, and lower Tertiary, by which these divisions were formerly known, have given place to Mr. Lyell's nomenclature, and although many objections have been made to it, nevertheless it is found quite convenient. The objections that I have heard amount to this, that with the progress of discovery the "per centage" must alter; but it must be recollected that the distinguished author never intended to limit it strictly to that found among the fossils first examined. Had he done so our Eocene would necessarily be referred to some other formation, for it contains not a single recent species.

The divisions of the Tertiary in general use with American Geologists are Eocene, Miocene, Pliocene, and Post Pliocene.

Eocene Formation.—The principal foreign localities of this formation are the London and Paris basins, and numerous others in various parts of France and Italy.

The Paris basin is deservedly the most noted, as the grand depository of the materials from which Cuvier restored so many strange Pachydermata.

The remains of fishes are numerous, particularly those of the family of Sharks, Ray and Sword fish. Turtles and other reptilia are not uncommon, and some remains of birds have been found. Among the Mammalian remains are those of Cetacea, the Monkey and Opossum.

Of mollusca, Gasteropods, and, with the exception of the Nautilus, the Cephalopoda, have disappeared.

In the United States this formation may be traced from Maryland to the Mississippi. The characteristic and most common fossils are Ostræa Sellæformis, Cardita Planicosta, and Turritella Mortoni.

Miocene Formation.—The beds composing this formation are generally made up of loose materials, such as sand, clay, gravel and marl, rarely indurated. It is seldom thick or continuous, being for the most part found in detached patches of limited extent. In the United States the thickest beds do not exceed 80 feet.

The formation designated in England as the "Crag," is Miocene. On the continent of Europe this formation is widely distributed.

In this country it is found extending along the coast of the Atlantic, from New Jersey to the Savannah, beyond which point, towards the South, it has not yet been recognized.

In genera the fossils differ but little from those of the preceding formation.

Post Pliocene.—In mineral composition the beds of this formation differ but little from those of the Miocene, excepting that they contain less lime. The fossils, with a few exceptions, are identical with the forms at present existing on the coast. The fossiliferous portion of the beds does not exceed four or five feet in thickness.

In the northern States beds of gravel, containing rounded and angular boulders, which have received the name of "drift," belong to this formation. The boulders have generally been transported from a distance, and have left markings on the rocks over which they passed in their journey, which indicate the direction from whence they came. These markings consist of striæ and grooves on the surface of the rocks. They bear so strong an analogy to similar markings on the rocks over which glaciers are known to have passed, that they have been referred to the same cause.

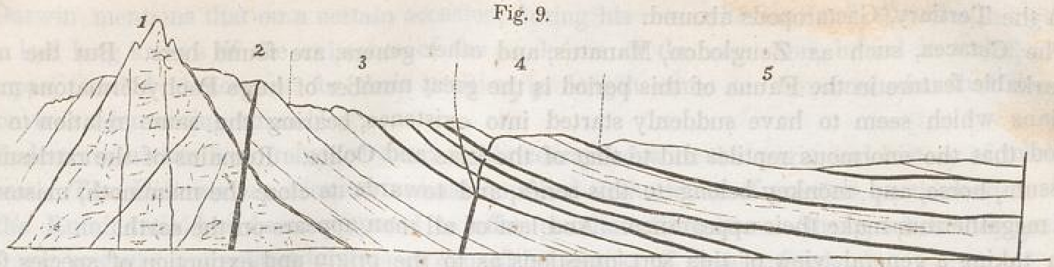
The glaciers consist of vast fields of frozen snow, covering the sides of mountains and extending into the valleys. Whenever the temperature of the air is sufficient to melt the surface of the snow, the water thus produced percolates into the glacier, where it is frozen. During this, expansion takes place, and the glacier moves onwards, tearing up, like a plough, the surface of the mountains, and bearing along with it vast masses of rock, intermingled with clay, earth, and gravel. Rocks are frozen into the bottom of glaziers, which score, by the immense weight of the mass, the surface of the underlying rocks. When the glaciers reach the point where the temperature is too high for them to exist, they melt and leave behind them their immense burden, consisting of the debris of the rocks over which their track lay. The melting of the snow and ice often produces floods that inundate the neighboring valleys, and have sufficient force to carry forward vast quantities of the materials brought down by the glaciers. Such a cause as this has been proposed to account for the transported rocks, where glaciers no longer exist.

The well known transporting power of icebergs has also been proposed. When the vast masses of ice that are constantly accumulating during winter in high northern latitudes, break loose from the shore, they carry with them masses of rocks and soil, which are distributed over the bottom of the sea, as the icebergs melt on their southern passage. This hypothesis, however, does not account for the striated surface of the rocks, for as the bottom of the ocean is covered with sand and mud, it is difficult to conceive how it could be striated or grooved. Besides, deposits thus formed would contain the remains of marine animals, which does not seem to be the case with the drift beds. On the other hand, the glacier hypothesis does not satisfactorily account for the vast amount of rounded and smooth water-worn pebbles, which abound in these beds, and which could only have resulted from the long continued action of water. It is highly probable, then, that the force which transported these beds was the result of the combined action of ice and water.

Alluvium.—This term has been applied to those sedimentary deposits that are going on at present on the banks of rivers and along the sea coasts. Such deposits, besides the remains of fluviatile and marine animals, sometimes contains works of art and human remains. They are, indeed, the only rocks in which the latter have as yet been found. The skeleton found in the West Indies some years ago was embedded in a deposit of recent shells, such as is at this moment in progress of formation on the coast of Florida.

The following section will convey a correct idea of the relative position of the rocks composing the crust of the earth, so far as it has been examined.

Fig. 9.



1—Granite. 2—Metamorphic rocks. 3—Palæozoic series. 4—Secondary series. 5—Tertiary series.

Succession of Organic Remains.—We may now take a slight restrospect of the Geological succession of organic remains, as developed by Geologists in all parts of the world. Commencing with the Potsdam sandstone of New York, which is the oldest fossiliferous rock of this country, we find that the first organic forms that occur are those of cellular plants, such as sea-weeds, and a small Brachiopodous mollusc, the Lingula. As we ascend in the Silurian series, corals and Crinoidea make their appearance in vast numbers, and the Brachiopods of various genera multiply.

The sub-kingdom Articulata is represented by numerous Trilobites, and the Cephalopodous molluscs by species having chambered shells.

Remains of fishes are found in the Silurian rocks of Europe, but they are exclusively those of the cartilaginous family; and no perfect forms occur till we reach the Old Red.

Towards the Upper part of the Silurian rocks of New York, plants that indicate the existence of dry land appear for the first time.

During the Carboniferous period plants seem to have attained the greatest development, and two species of Poa, the only fossil grasses known, are found in the coal formation of England; and, what is equally curious, the first insect appears here.

The Trilobites disappear altogether with the carboniferous rocks, while voracious fishes, of great size, inhabited the seas throughout the entire period.

In the Magnesian limestone remains of reptiles are found for the first time.

In the New Red we find the earliest evidences of the existence of birds; and, in Europe, Batrachian reptiles have left their tracks and some bones in this formation.

In the Lias and Oolite the class Reptilia is represented by the most extraordinary forms. The Enaliosauria of this period have left behind them no representatives, unless the "Sea-serpent" should turn out to be a veritable inhabitant of our seas. In the Oolite we find the first mammalian remains, the jaw of an Opossum.

The noble tree-ferns of the Carboniferous period have disappeared, and a few palms are found lingering behind. Insects are now, for the first time, abundant; and in the Wealden formation the remains of lizards of enormous proportions exist.

In the Cretaceous system some remains of the Saurians of the preceding groups are found, but the most remarkable reptile peculiar to this period, is the Mosasaurus.

Cartilaginous fishes, of the Shark and Ray tribes, are numerous, but the fierce Ganoids begin to give place to the Ctenoids and Cycloids, which make their first appearance here. With the exception of two genera, the existence of the Ganoids terminates with the Cretaceous system, and, with a solitary exception, the Cephalapods disappear altogether with these rocks.

In the Tertiary, Gastaropods abound.

The Cetacea, such as Zeuglodon, Manatus, and other genera, are found here. But the most remarkable feature in the Fauna of this period is the great number of huge Pachydermatous mammalians which seem to have suddenly started into existence, bearing the same relation to this period that the enormous reptiles did to that of the Lias and Oolite. Remains of the rattlesnake, opossum, horse, and monkey belong to this series, and towards its close the mammoth, mastodon, and megatherium make their appearance. And last of all man appears on the earth.

In taking a general view of this sort, questions as to the origin and extinction of species force themselves upon the mind of the most thoughtless. Did species first come from the hand of the Creator in the form in which we find them, or did they pass through a series of metamorphoses, by which they were gradually changed and perfected? A superficial observer, in casting his eye over a collection of organic remains, would no doubt be struck with the evidences of progression that it presents. But a thorough examination, supposing he had the patience to make it, would satisfy him that this progression, so far as it exists, is the result of a design, having for its object adaptation to external existing circumstances, and not giving the slightest countenance to any development by metamorphosis or transmutation.

Some writers have attempted to account for the origin of life by supposing that animalcules were living atoms of elementary matter, which, by their aggregation or coalescence, produced higher animals.

Akin to this theory is that of "spontaneous generation," which is often flippantly expressed by the phraseology—"Matter placed under favorable circumstances may produce life." The experiments of Cross, who it was supposed had produced living infusoria by galvanic action, and existence of the intestinal and other worms where it was once found difficult to account for their presence, have all been adduced in proof of this theory.

With regard to animalcules, it is now well known, from the labors of Ehrenberg and others, that the most minute of these little forms are well organized animals, presenting the relations of parent and offspring just as distinctly as they are found in higher organisms. Ehrenberg and Agassiz have repeatedly seen them laying eggs, and studied the form and growth of the young within these eggs. These facts were not known to these who first proposed the theory of "living elementary atoms." We have not the slightest evidence, any where, of the union of organized beings, to form a *higher* animal. Had such existed, it would have been long since discovered, if it were not sufficiently opposed to the whole plan exhibited in animated nature.

"Spontaneous generation" takes for granted what it should prove, for it supposes matter endowed with the attributes of life, and capable of performing one of its highest functions, before life has yet existed, which is sufficiently absurd.

Cross's experiment proves too much: for the animal supposed to be produced belongs to the class Articulata, which stands high in the scale of being, and includes forms of high organization. It should have commenced lower in the scale. Besides, the experiments, or rather their results, are far from being considered as conclusive, by those best capable of appreciating such processes.

The worms found in the intestinal and other cavities of animals are frequently alluded to, and are even supposed to originate in those cavities. It is not surprising that such opinions once existed, when science could offer no better theory—and the uninformed are most given to theorize.

Darwin mentions that on a certain occasion, during his researches in South America, his guides, who had long known of the existence of the skeletons of the mastodon, buried in a cliff, on the Pampas, puzzled to account for their position, at length came to the conclusion that the mastodon was a burrowing animal!

Modern researches have removed every doubt connected with the origin and history of intestinal worms. The *Distoma hepatica*, an animal confined to the livers of animals, particularly to those of the Ruminantia, has been supposed to offer peculiar difficulties. Sheep, when they graze in low, wet pastures, are subject to diseases caused by attacks of these animals.

A Swedish naturalist has the merit of being the first to point out the origin of these worms. He observed that at a certain season a species of fresh water mollusc was infested with small worms. He found them at first attached to the skin, at a time when they abounded in the water. They bury themselves in the animal, where they remain until one of those changes takes place, to which insects are subject. It is now provided with the means of penetrating the body, which it does till it reaches the cavity where the viscera are contained, to which it attaches itself, and where it continues to live and propagate.

Prof. Eschrich has investigated with equal success the history of intestinal worms. He observed that periodically fishes were found with long worms in the alimentary canal, while at other times they disappeared altogether. Following up these investigations, he traced these worms through all their stages of growth, until they became long worms with articulated bodies and a small head. He observed that they shed the greater portion of the body at certain seasons; he found, moreover, that each joint of the portion thus cast contained hundreds of eggs, which, escaping into the water, would be swallowed by fishes along with their food, and would of course re-appear in the form of worms in the alimentary canal.

One of the most curious facts observed during the investigation of the Natural History of Distoma, is that this animal is subject to several metamorphoses, and it requires several generations for the newly hatched animal to arrive at the state of the original parent.

If, then, some of the most difficult cases connected with the origin of these obscure forms of being, have been thus successfully investigated, is it not reasonable to conclude that every case may admit of a like satisfactory explanation? Let us now take a brief glance at the transmutation theory.

Life somehow commenced, Maillet and Lamark supposed the earlier organisms endowed with a power which they called appetency. This power, exerted for a long time in a particular direction, produced new organs or modified the old ones. For instance, one can suppose that a primeval oyster, tired of lying on its side, might entertain an intense desire to promenade the beautiful coral groves in its neighborhood. Such a desire, long continued, say these philosophers, would produce an extension of the abdominal muscles, which, after a while, would be protruded like a foot, by means of which the oyster could move about. The shell of the oyster would be inconvenient, on account of its unequal valves: some strong desires to remedy this, would no doubt occupy the mind of the oyster, and the result would be that, in a few generations, this shell would be altered to one of symmetrical form, such as that of the clam, which is far more convenient for locomotion. The desire to feel and to see would next be felt, and the tentaculæ and eyes of the gasteropod would appear. These causes continued, the oyster, in its upward progress, would arrive at the organization of a well developed Gasteropod. And in this way the process from an oyster up to a man seems quite easy.

But the following extract from the Teliamed of Maillet will serve as a specimen of their own logic on this subject.

"Winged or flying fish, stimulated by the desire of prey or the fear of death, or pushed ashore by the billows, have fallen among reeds or herbage, whence it was not possible for them to resume their flight to the sea, by means of which they had contracted their first facility of flying. Then their fins, being no longer bathed in the sea-water, were split, and became warped by their dryness. While they found, among the seeds and herbage among which they fell, any aliments to support them, the vessels of their wings being separated, were lengthened and clothed with beards; or, to speak more correctly, more justly, the membranes which before kept them adherent to each other, were metamorphosed. The beard formed of these warped membranes was lengthened. The skin of these animals was insensibly covered with down of the same color with the skin, and this down gradually increased. The little wings they had under their belly, and which, like their wings, helped them to walk in the sea, became feet, and served them to walk on land."

It is proper to state that modern philosophers of this school have given up the "appetency" portion of the theory, and only insist upon a series of gradual transmutations or metamorphoses, such as that which the frog undergoes in its passage from the egg to the perfect animal—all the result of external circumstances.

The coarse hair of the dog of warm climates, becomes fur in high northern latitudes; and the evergreen of the South becomes deciduous when removed to the North. What was at first accidental, in time becomes permanent.

The setter is taught to set game, but the puppy, its offspring, sets by instinct: what was at first a mere habit, acquired by education, now becomes a permanent principle.

Such facts as these, when strained beyond their legitimate application, become absurdities. Does it follow that because the hair of the dog is changed, to adapt it, as a covering, to external circumstances, that he would ever become a lion or a monkey? or that, because the educational habits of the setter are transmitted to its offspring, in time it would be able to solve a problem in geometry? Yet it is reasoning very like this that those employ who teach changes by development from lower to higher forms of existence.

There is a dangerous ambiguity lurking behind this word "development," that, I am persuaded, has deceived many. In the geological succession of animals, there is very evident gradation from the lowest *groups* to the highest, and this has been mistaken for development. The changes that take place in the egg, from the commencement of incubation to the production of the living bird, are called development. The changes that take place in the life of the insect, between the caterpillar and butterfly states, are metamorphoses. Now neither of these changes can be applied to the gradation observed in the scale of being.

When the frog first leaves the egg it has gills for breathing in water, a tail, and all the habits of a fish; after a while legs appear, and the tail, after another short interval, disappears: the tadpole now begins to breathe air, and finally leaves the water, a small but well formed frog. Here is an example of metamorphosis, which, if it could but be seen to take place between two species, it would be all that could be desired to account for the gradation observed in nature. But these changes are as much a part of the nature of a frog as its long legs and aquatic habits. The frog emerging from the tadpole state is as much a frog as its parent. Had it appeared with the rudiments of wings, we could at once see how it may, in time, become a bird.

There is, however, some analogy between the succession of fossil fishes and reptiles, and the changes that take place during the embryonic development of these animals. Agassiz has observed that the changes that take place in the embryo of fishes represent the order in which fishes occur in the older fossiliferous rocks.

The embryo fish is first cartilaginous and heterocircal, from this it passes to the homocircal and osseous state. Now we know that the first fishes were heterocircal and cartilaginous, and were succeeded by homocircal families.

Reptiles, too, in the egg, begin with biconcave vertebræ, and terminate with the concavo-convex articular surfaces, which is the type of living saurians. Now we have seen that the prevailing form of the earlier reptilian vertebræ was biconcave. These analogies are curious and interesting, and afford characters that determine at once the order in the scale of organization that the forms thus typified should occupy. As the development in the egg is from lower to higher forms, the reptiles with biconcave vertebræ, and fishes with heterocircal tails, must stand below the others in the scale. But such facts afford not the slightest evidence of the transmutation or self-development of species.

When it is urged that no Naturalist has seen in existing nature any such passage from one species to another, the reply is that the time is not sufficient for their observation—"the metamorphoses of species proceed so slowly with regard to us, that we can neither perceive their origin, their maturity, nor their decay." But to the organic forms preserved in the solid crust of the earth, this want of time cannot apply: with them there was time enough. Let us then see whether any evidences of such metamorphoses present themselves. The first organisms belong to the Mollusca and Articulata: now if we compare the Brachiopods of that period with the few that exist at the present day, we cannot perceive that any progress has taken place in this oldest of families. Cephalopods have made no advances in organization or numbers, but, on the contrary, almost entirely disappeared with the upper part of the Cretaceous system. Besides, the first of the Cephalopoda belonged to the higher and not the lower division of the class.

The same is true of Reptiles: the Labyrinthodon of the New Red, was far from being the lowest of Batrachia. The long period during which the Enaliosaurs peopled the Liassic and Oolite seas, presented a good opportunity of observing any transmutation that may have taken place in these reptiles. The Ichthyosaurus, for instance, might be expected to lose some of those characters that indicate affinity with fishes, and become a Plesiosaurus, but no such change can be observed; on the contrary, they were, from the beginning of their existence, contemporaneous, and from the very beginning presented the same characters that distinguish them at the last.

After a profound examination of the reptiles of this period, Prof. Owen comes to the conclusion "that the different species of Reptiles were suddenly introduced upon the earth's surface." "Upon the whole, they make a progressive approach to the organization of the existing species, yet not by an uninterrupted succession of approximating steps." "But, on the contrary, the modifications of osteological structure which characterize the extinct Reptiles, were originally impressed upon them at their creation, and have been neither derived from improvement of a lower, nor lost by progressive development into a higher type."

And the same conclusion is true of the other groups. The gradation is not from one species to another, but a progression of classes, which was adapted to a corresponding progression in the state of the earth's surface; and although we cannot show what the actual condition of the inorganic world was, at the time of the introduction of each of these classes, we have every reason to believe the classes introduced were created with express adaptations to those conditions.

We find everywhere among fossil groups of successive formations marks of adaptation to preceding conditions. Crustacea follow the fucoids upon which they fed; the voracious Sauroid fishes are introduced after a supply of food was prepared by the existence of other animals. Huge Reptiles next appear, which preyed upon these. Birds come into existence after the appearance of dry land, as indicated by land plants. Insects precede the Insectivora. Herbivorous animals appear still later, when plants were in number and kinds sufficient to afford them proper food, and are followed by carnivorous animals, which prey upon them. Last in the series man appears.

Consistency of Modern Geology with the Mosaic account of the Creation.—When Geologists first announced the fact that deposits of great thickness, abounding in the remains of animals that once lived, existed in the earth's crust, and that all this could not be explained on the supposition that the age of the earth was only 6,000 years, Geology was considered, for a while, as opposed to the Bible.

Time was when Astronomy stood in the same relation; and although it is now known that it is the motion of the earth and not that of the sun that produces the phenomena of day and night, yet no one thinks the authority of the Scriptures lessened, or has his belief disturbed by this—and for the simple reason that he knows that the Bible was intended to be a code of moral and religious laws, and not a text book of Astronomy. And this science is now properly regarded as the handmaid of religion, in expanding and ennobling the mind, by elevated views of the Creator's works.

It is not to be supposed that Moses, in the account he gives of the creation, intended a system of chronology: his great object seems to be to impress his readers with the fundamental truths that the world was not eternal, but the work of the Almighty, and that man, like the rest, had a beginning—in a word, to show them how, and not when, the world was made.

It must be borne in mind that the question is not between the facts of Geology and the credibility of the Mosaic Account of the Creation, but between those facts and the literal interpretation of that account.

It is acknowledged on all hands that the deposition of strata of rocks six or seven miles in thickness, containing organic remains, must have occupied, according to all the laws governing matter, an immensely great period of time. It was usual, at one time, to refer the phenomenon of the distribution of organic remains in these rocks to the Deluge; but no one, who has ever examined a fossiliferous deposit for five minutes, can hold such an opinion. The manner in which fossil shells are embedded shows most conclusively that the animals to which they belonged lived and died where we find them, and that they could not have been disturbed by the waters of a deluge.

There are, I believe, those who suppose that the world is not the result of a long continued series of events, but that it was created at once, and as we find it. Such an opinion can only be held in direct violation of all natural laws and analogies, and by forfeiting all the arguments and principles of Natural Theology. For if, when we examine the curiously organized eyes of the Trilobite, embedded in the older rocks, we are not allowed to infer adaptation to light and other external objects, why then Paley's "watch" presents no evidences of design, and the arguments drawn from it are worthless.

The interpretation of the Mosaic narrative of the creation that is most in accordance with the discoveries of Geology, is that which supposes the "beginning," mentioned in the first verse, to be a time immeasurably distant from the "first day," mentioned in the fifth verse, and that in the interval between this "beginning" and the "first day," all the phenomena of Geology were brought about; and that the subsequent days refer to the present state of the earth's surface, and to the creation of existing races of animals and plants. This is the view taken by many Geologists, and by those Divines who have examined both sides of the question.

This interpretation was not first proposed by Geologists: some of the Fathers of the Church separated the "beginning" from the days of creation; and the notation of Luther's Bible goes to show that he supposed the creation to commence with the third verse of the Mosaic narrative.

Others suppose that the days of the Mosaic narrative are to be understood figuratively, for periods of time, of indefinite length. But whatever view be taken of this subject, no one need attempt to press Geology into any irreligious service. No science can be more worthy of the attention of the Christian student, for none can lead him more directly to the Creator, as the First Cause. It takes him back to the time when neither man nor beast nor bird nor creeping thing nor plant existed, and when even the oldest rocks had a less permanent form. In a word, it shows him that all save the Almighty had a beginning—that He alone is eternal.