interesting area of it is in Ohio and Kentucky, sometimes called the "Cincinnati Axis," because the central anticlinal ridge passes near this city. According to Dr. Newberry, this Cambro-Silurian ridge was elevated before the deposition of the first beds of the Silurian, as the latter are found upon both its slopes, and the ridge may have been 2,000 or 3,000 feet high. This area is repeated about Nashville, in Tennessee; and these areas, connected beneath the higher rocks, must have been a tract of dry land separating the Appalachian from the Illinois coal-fields in a later period. The Trenton limestone is one of the best known of the Cambro-Silurian series. As a whole, the series is calcareous, and must have indicated the area occupied by an ocean, as limestone is usually a chemical deposit from saline waters.

The Silurian formations are also widely distributed over the country. As the Atlantic and Adirondack areas of dry land were now united, the Silurian formations lie along their inner border, from Alabama to New York, and thence westerly to Minnesota, and are rare to the east. The Canadian basin is chiefly of the Cambro-Silurian.

The extensive salt deposits of New York and Ontario were formed in the Onondaga salt period. There must have been an inland sea, possibly with a narrow outlet along the Hudson, but broad and deep in Western New York and Ontario, in which the waters evaporated, leaving behind their dissolved compounds in the form of salt. Beds of rock-salt have not been found in this area, but the strata deep down must be largely composed of it, so as to afford a very strong brine, which comes to the surface in springs and artesian wells.

The life is generically like that of the preceding series. There are plenty of corals, star-fishes, crinoids, trilobites, mollusks, and brachiopods, all peculiar to this age. In the waterlime group an interesting group of crustaceans reach their maximum development. They are represented by the *Eurypterus* and *Pterygotus*, animals somewhat like the modern king-crab. In Europe the latter attained a length of five feet, but no such giants have yet been discovered in America. The European strata of this age exhibit a few fish.

For the next group we have the name of Erie Division of the New York geologists, corresponding to the Devonian of Murchison in Europe. In view of certain difficulties connected with the grouping of these strata abroad, Dr. Dawson has suggested that we use only the name of Erie, or Erian, for these formations in this country. These rocks have an extensive development along the Atlantic border, not continuous, as in Quebec and New Brunswick, Maine, New York, Pennsylvania, and southwards.

A more widespread area pushes westward from New York into Ontario, Ohio, Indiana, Kentucky, Michigan, Illinois, Wisconsin, and Ohio. The rocks of this series are scarce in the Rocky Mountains.

The life is a great advance upon that of the Silurian. Terrestrial plants, reeds, rushes, and trees made their appearance, and in great numbers, in the Hamilton and Chemung ages. In the limestones of the Upper Helderberg there were enormous ganoid fishes, more terrible than sharks. The lower forms of life, as mentioned before, still existed, but under different specific forms. Limestones were not so abundant, and therefore the corals are not preserved so numerously as before. No evidences of vertebrate life above the fish type have yet been found in the Devonian in any part of the world. If we style the earlier Paleozoic the Age of Trilobites, the Devonian was certainly the Age of Fishes, not of the common type prevalent at the present day, but one resembling obscurely our sturgeons, gars, sharks, and chimæras.

The Carboniferous System of rocks is perhaps of the greatest industrial importance to the country of any of the whole geological series, on account of the coal and iron ores contained in them. The lower divisions everywhere encircle the great coal basins, which have been already described with some detail. In the more western coal-fields the lower division is chiefly composed of limestones. There is a great difference in the thickness of the strata in the interior and along the eastern borders, the latter being several times the former in bulk; and the same is true of the whole Palæozoic column. The maximum thickness in the interior is 6,000 feet, while along the Appalachians they amount to 50,000. The Carboniferous system is 14,000 feet thick in Nova Scotia, 6,000 in Rhode Island, over 9,000 in Pennsylvania, 853 feet in Michigan, 1,000 in Iowa, 1,850 in Illinois, 1,400 in Missouri. These facts indicate that the current transporting material was most powerful in the east, while there may have been oceanic waters over the interior, or a great extension of the Gulf of Mexico.

The coal seems to have been mostly a terrestrial accumulation of leaves, bark, and other vegetable debris, in the lowland forests of the interior. The level of the land was so low, that there were constantly repeated overflows upon it, so as to bring in layers of mud, limestone, and sand over the vegetable beds. The cannel-coals, however, seem to have been an aqueous deposit of vegetable mud, and the asphaltic coals of West Virginia and New Brunswick occupy fissures in the strata like veins, as if once in a liquid condition.

The coal measures were followed by the Permian deposits, which seem to be confined to the western border of the Missouri coal-field, in Nebraska, Kansas, and Indian Territory. The system seems to have been developed in this country in an inferior way, and is of much less consequence here than in Europe.

Besides the prolific plants of the Carboniferous, there was a great abundance of enormous amphibian reptiles.

MESOZOIC.

The distribution of land and water was very different at the beginning of this period from what it had been hitherto. The great period of elevation in North America seems to have been at the close of the Palæozoic. Instead of an ocean from the Lakes on the north, to the Appalachian on the east, and extending to the Rocky Mountain range, and possibly covering them, we have one limited easterly by the Missouri Coal Basin, or a ridge from Red River, Minn., to Texas, but with no practical limit to the north and south, and on the west the Rocky Mountains, from Montana to Santa Fé, and a large ocean along the Colorado River and its sources. The Atlantic border was farther inland in the Southern States than now, while the continent must have stood from fifty to eighty miles farther out to sea in the latitude of New York. Along the Atlantic border there were several estuaries: one running to the New Hampshire line through Connecticut and Massachusetts; a second from the Hudson River opposite New York into Virginia; a third near Richmond, Va.; other limited areas in Virginia; an extensive estuary from the south part of Virginia into the interior of North Carolina; another from near Raleigh into the edge of South Carolina. The rocks of these large estuary deposits are chiefly sandstones, with coal-beds.

The Triassic rocks to the west are chiefly clays and marls abounding in gypsum. The largest area of this description extends along Red River from Arkansas to near Santa Fe, underlying the Llano Estacado of Texas. It has been explored by Marcy, Marcou, and Newberry. Prof. Marcou thinks he can identify over this area the equivalent of the three members of the Triassic in Europe: first, the "Bunter sandstein," or variegated sandstone; second, the "Muschelkalk," beds of red clay, containing often immense masses of gypsum, with layers of dolomite and sometimes beds of rock-salt; third, the "Keuper" or "Marnes irisees," composed of sandstone and brilliantly colored sandy calcareous clay. These groups are thought to be 4000 or 5000 feet thick.

The fossils in these western Triassic areas are scarce. Those upon which the identification is based are coniferous plants and ferns. In the east we have the remains of astonishing reptiles, reptilian birds, birds of gigantic dimensions, and numerous plants. The famous tracks of the Connecticut Valley in New England are the principal evidences of the existence of a very remarkable reptilian assemblage. These were described first in 1836, by the late President Edward Hitchcock. His latest conclusions give 150 as the number of species of *Ichnozoa*, or animals made known by their tracks, divided among marsupials, birds, reptilian birds, reptiles, fishes, insects, mollusca, and worms. The Hitchcock Ichnological Museum, at Amherst College, contains over 20,000 impressions made by the feet of animals. The discovery of ornithic reptiles, first surmised by President Hitchcock from the foot-marks, and confirmed by the discovery of the bones in other parts of the world, have led many hastily to conclude that none of the animals were birds. Seventeen of the animals must have been birds, since none of their impressions indicate more than two feet, and they had an enormous stride, like the ostrich and flamingo. These birds are thought to be allied to the Cursores. The largest must have equalled the Dinornis of New Zealand, ten feet high. The reptilian birds are those with a general ornithic shape, but displaying elongated caudal appendages, and small front limbs, instead of wings. These front extremities were occasionally brought to the ground in walking.

The Jurassic series has been described in the Rocky Mountains by Meek and Hayden. American geologists do not generally accept the argument of Prof. Jules Marcou in regard to strata of the Jura, on the Llano Estacado, in Texas. The summit of this elevated plain is thought to belong to the Cretaceous, which comes next in order.

The Cretaceous formation has an enormous development in the United States. It can be traced first along the Atlantic border, from Long Island to Alabama. Where it does not show at the surface, it may underlie the tertiary, as it crops out occasionally in the Carolinas and Georgia. Curving around the older groups in Alabama, it passes north to the mouth of the Ohio River. On the west of the Mississippi, in Missouri, there is a small outcrop of the Cretaceous, but very little in Arkansas. From this point south and west and north, its area becomes very extensive, as appears upon the map. It occurs abundantly over the great plains, and in numerous valleys among the Rocky Mountains, in California, Oregon, etc. A very good bituminous coal comes from it in Wyoming, California, Colorado, Washington Territory, Vancouver's Island, Alaska, etc. Viewed in its most general aspect, New Mexico may be said to consist of a plateau of Cretaceous rocks, the continuation geologically of the Llano Estacado, with an elevation of from 5,000 to 8,000 feet above the sea. The lowest member is a yellowish sandstone, containing angiospermous leaves, as those of the Platanus, Salix, Sassafras, Liriodendron, Magnolia, Poplar, Oak, etc. These are the earliest traces of this style of plant-life to be found in the stratigraphical series. The area of this layer indicates a wide-spread submergence — continental almost — where the sandstone was being deposited. Above this member the Middle Cretaceous appears, a calcareous, sometimes chalky deposit, 1,500 to 2,000 feet in thickness, containing gasteropod shells, ammonites, sharks' teeth, and the bones of many curious reptiles. To account for the accumulation of this calcareous mud, we must believe the submergence to have been deeper than in the preceding period.

The Upper Cretaceous member is developed more to the north in Dakota, Wyoming, Colorado, etc. It contains the beds of coal which will prove quite valuable in that region which is destitute so largely of fuel, either of trees or the best of stone-coal. This division was at first referred to the Tertiary; but now Hayden, Newberry, Cope, and others, are agreed that the beds belong chiefly to the Cretaceous.

CENOZOIC.

Dr. F. V. Hayden has made extensive explorations among the Tertiary areas of the West. The Rocky Mountain region seems to have arisen from its depressed condition during the Cretaceous, and everywhere from the Pacific Ocean to the Missouri River was covered over by a large number of fresh-water lakes. Dr. Hayden has given local names to many of these Tertiary basins. Among them are the following: First, of the Lower Tertiary, Fort Union group, Judith River beds, Raton Hills group, Canyon City group, Bear River group. These all contain lignites. Second, of the Middle Tertiary, Bridger group, Green River group, Wahsatch group, White River group, Washakie group, Wind River deposits, Monument Creek group. Of the Upper Tertiary, the Loup River beds and Salt Lake group. Full descriptions of the relations of these beds have not been given. Some contain very interesting remains of extinct mammals — especially of the Pachyderms, animals allied to the living tapir, and corresponding to the Paleotherium, etc., of the Paris Basin. There are also camels, horses, lions, etc.

In Utah, Nevada, California, Oregon, there are many lacustrine areas and deltas. Some of the former are saline, where the lake has no outlet; others are beneath the level of the Pacific. Other lakes contain boracic acid, which is manufactured in the well-known borax of commerce; others still have left behind enormous deposits of diatomaceous earth or polishing-powder. The gold obtained from detrital rocks in California is more from the Miocene and Pliocene than from the Alluvium. The Tertiary rocks of the Pacific slope are of enormous thickness.

A glance at the other portions of the map shows a strip of Cenozoic strata bordering the ocean from Mexico to Massachusetts, with two important expansions: the first, the enormous delta of the Mississippi River, and the second the projecting peninsula of Florida. The eastward curvature of the Mississippi near its mouth is due to the course of the Cretaceous ridge from Lake Bistenau to the Atchafalaya Bay now mostly concealed by the Tertiary. The few remaining cretaceous outliers show the presence of salt, gypsum, and sulphur. The Florida peninsula has been built out by the growth of coral reefs. As fast as these are formed they attract the fine mud brought down the Mississippi into the Gulf of Mexico, and thus in immense eras of time new land is formed. Estimating from the observed rate of growth of coral reefs, it has been suggested that the original construction of Florida occupied 140,000 years of time.

The country north of the Ohio River, and the valley of the Mississippi River to the height of 700 feet, is covered with detritus carried southerly by glaciers and icebergs since the Tertiary period. It is probable that this drift was transported mainly by glaciers, when the country was much more elevated than at present. Where the southern extremity of the land-ice came in contact with the ocean, icebergs must have been broken off, and a large amount of material transported by them — perhaps 600 to 800 miles. Geologists are not yet agreed in respect to the precise character of the glacial agents, nor how extensively they have acted. The glacial drift does not seem to have covered the Rocky Mountains other than as a few small local glaciers upon the Pacific slope of the Sierra Nevada. Transported boulders have been found at the height of 5,800 feet upon Mount Washington, N. H.

NOTE. — The accompanying map has been compiled principally from data furnished by the numerous public surveys undertaken by the State and General Governments, supplemented by private explorations. Much of the material that has been used is in manuscript, and has been prepared in the several States by the best informed geologists familiar with the details of each district.

GEOLOGICAL DESCRIPTION.

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THE following is a list of the formations found in the United States, compiled from the various surveys in accordance with the recognized principles of classification. The most recent deposit is at the head of the list.

CENOZOIC.	Tertiary.	Alluvium, or Post-Pliocene,	Iron age. Copper age. Stone age. Drift.	
		Pliocene,	Sumter beds.	
		Miocene,	Loup River group. Yorktown group. White River group.	
		Oligocene,	Vicksburg group. Jackson group. Claiborne group.	
		Eocene,	Buhrstone group. Flatwoods Clay group.	
MESOZOIC.	Cretaceous.	Later,	Fox Hills group. Fort Pierre group. Niobrara group.	
		Earlier,	Fort Benton group. Dakota group.	
	Jurassic,		Jurassic.	
	Triassic,		Clays, Gypsum beds, and Sandstones.	
	Permian.		Permian. Permo-Carboniferous.	
PALÆOZOIC.	APPALACHIAN PALÆOZOIC DAY.	Carboniferous.	Seral,	Coal Measures. Millstone grit. Mississippi or Mountain limestone.
			Umbral,	Conglomerate, Catskill or Marshall group.
			Vespertine, Ponent,	Chemung group. Portage group.
		Devonian.	Vergent,	Huron shale. Hamilton group.
			Cadent,	Upper Helderberg limestone. Schoharie grit.
			Post-Meridian,	Cauda Galli grit. Oriskany sandstone.
		Silurian.	Pre-Meridian,	Lower Helderberg limestone. Waterlime group. Onondaga salt group. Niagara group.
			Scalent,	Clinton group. Medina group.
			Surgent, Levant,	Lorraine shales. Utica slate. Trenton limestone.
			Matinal,	Isle La Motte limestone. Birdseye limestone.
		Cambro-Silurian.	Auroral,	Chazy limestone. Quebec group. Calciferous sandrock. Potsdam sandstone. Georgia slates.
		Cambrian.	Primal,	Braintree slates. Merrimack and Coos groups.
EOZOIC.			Huronian. Labradorian. Laurentian.	

The primary division of the stratified rocks is based upon the character of the organisms which existed during the several periods. Relics of life have been found in the very lowest strata with which geologists are acquainted. Hence the term *Azoic*, signifying the absence of life, is no longer appropriate. The existence of plants is indicated chiefly by the presence of beds of plumbago and of iron ore; and the evidences of animal life depend upon resemblances to the *Protozoans*, or sponge group, in certain serpentines. Both classes indicate the very simplest forms of vegetable and animal life, such as would naturally have been introduced first, in accordance with the law of progress in the organic creation. The name *Eozoic* signifies the dawn of life. The rocks in the Laurentian, Labradorian, and Huronian series are altogether crystalline, having been altered by the process of metamorphism from the original sediments of heterogeneous combinations into crystalline schists, whose component crystals are arranged by chemical forces in layers. Fossils of higher grade than the *Eozoon* may have been present, and have been obliterated during the process of change. In America, the Eozoon has been found in Ontario, New York, and Massachusetts. It occurs only in the Laurentian.

The *Palæozoic* division includes an ancient type of life, largely of invertebrates. The lower Cambrian is almost unfossiliferous; and in the Carboniferous the Amphibian reptiles are abundant, and of large size and a considerable degree of perfection. The general character of the life is much unlike anything now existing.

The *Mesozoic* division includes a *middle* type of life, including the highest development of true reptiles. This indicates a great progress over the Palæozoic. The latest division, or the *recent* type of existence, is characterized by the presence of animals and plants closely allied to existing races, in which the Mammals or Quadrupeds predominated. Man came into being towards the close of the *Cenozoic*.

EOZOIC.

The scale of the map forbids the separate representation of the Laurentian, Labradorian, and Huronian systems. Looking at the general arrangement of the whole, we perceive three prominent areas. The first is like the letter V, one arm resting upon the Atlantic at the north side of the river St. Lawrence, extending to Wisconsin, where the apex of the letter is reached, and the other arm starts off for the Arctic Ocean. The second area is approximately parallel to an arm of the V, extending from New Brunswick to Alabama. The third area extends northerly and west of north along the Rocky Mountain region. If the second area were extended to meet the third, there would be two V-shaped areas, one resting within the other. The Eozoic islands in Minnesota, Missouri, Arkansas, and Texas suggest a single range, more nearly parallel to the western than the eastern arm of the outer V.

These arrow-shaped areas may indicate the shape of the North American continent at the beginning of the Palæozoic age, and may be compared to a skeleton. In the subsequent periods the bones became covered with flesh, — that is, the long and narrow islands became wider, or new formations gathered about them, and the interspaces were consolidated with the original areas.

The Laurentian rocks are supposed to comprise the greater portion of the areas colored Eozoic. The name is derived from the Laurentine Mountains in Quebec, and was first applied to a geological system in 1855 by Sir W. E. Logan. The system is well developed in northern New York, in New England, and south-easterly through New York, New Jersey, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, Georgia to Alabama. If a subdivision of the Laurentian be found practicable, it is likely that the Adirondack portion will be shown to be older than that of the Atlantic border. The latter division is even now by some geologists regarded as metamorphic Palæozoic.

The Eozoic islands in the centre of the continent are all Laurentian, as well as the central portion of the same area south of Lake Superior. The Rocky Mountain area has been little studied, but it seems to be mostly Laurentian. There are many interesting islands of it in Dakota and Montana, of which the Black Hills is the most conspicuous. The range runs down to Colorado, Utah, and Arizona, where it is well filled with metalliferous veins. The western border of this metamorphic range, along the Sierra Nevada ranges, seems to be of Triassic or Jurassic age. The formation appears also at the bottom of the immense canyon of the Colorado River in Arizona.

The Labradorian system has been sparingly studied, but it seems to lie in small areas unconformably upon the Laurentian, in Quebec, Ontario, New Hampshire, North Carolina, New York, and perhaps in the Black Hills and the Indian Territory.

The Huronian system follows the Laurentian Atlantic belt along its entire length. It is well developed in Virginia, North Carolina, and Vermont, and is in these States the basis of the auriferous veins. Some geologists have called these talcose rocks an altered portion of the Cambro-Silurian, or the "Quebec Group." The name was applied in 1855 by Sir W. E. Logan from its great development about Lake Huron. The iron region of Michigan is Huronian, and also the "Plateau des Couteau des Prairies" in Minnesota and Dakota. The latter area consists largely of nearly horizontal strata of quartzite, in which is imbedded the famous pipestone of the Sioux Indians. Some British geologists represent two areas of Huronian, extending from British North America into Idaho and Washington Territories.

The best iron ores in the country belong to the Eozoic rocks, in Ontario, New York (Adirondacks), Michigan, Missouri, etc. They are the magnetic and specular oxides. The iron from the Labrador rocks is apt to be very titaniferous, and consequently inferior for smelting purposes. Our gems and rare minerals are most commonly derived from these crystalline strata.

PALÆOZOIC.

American geologists have, of late, improperly grouped the Silurian system, after the lead of certain Europeans. Using a strict regard to laws of priority, the Cambrian should include the Lower Silurian strata, as usually understood in this country. But a compromise between the opposing claims by the Government surveys of Great Britain used the name of Cambro-Silurian for the formations claimed by both Sedgwick and Murchison, the original discoverers of the Cambrian and Silurian systems respectively. The Cambrian should embrace all the rocks to the base of the Calciferous sandrock above the Huronian, and the Cambro-Silurian those from this horizon to the top of the Lorraine shales or the base of the Medina group.

There are two parts to the Cambrian. The first consists of the portions not yet recognized as fossiliferous in this country. The rocks are largely mica schist, quartzites, and andalusite or staurolite slates, such as abound in New England, Pennsylvania, the Carolinas, Georgia, etc. In New England the micaceous quartzites have been referred, in part, to the Merrimack group, and the andalusite slates to the Coos group. These names were introduced by the New Hampshire Geological Survey.

The Merrimack group seems to start from the neighborhood of Worcester, Mass., and pass northeasterly down the Merrimack River to its mouth, whence its name. Rocks allied to them appear along the coast in New Hampshire and Maine, and also in Coos Co., N. H. The andalusite slates follow the Merrimack group in Massachusetts and the lower part of New Hampshire. They crop out on the east flank of the Mount Washington range also. They exist in great amount in North Carolina, and probably further south. The recognition of andalusite and its related mineral compounds, as guides to the age of formations, was first suggested by Dr. T. Sterry Hunt, and the author proposed the name of Coos for them from the great development of the series in the most northern county of that name in New Hampshire. Being recently proposed, there has not been sufficient opportunity for the geologists of the country to pronounce upon the value of the suggestions.

The other division of the Cambrian is well known. The lower portion consists of dark clay and flinty slate in east Massachusetts, New Brunswick, and Newfoundland, holding the trilobites *Paradoxides* and *Ellipsocephalus*. These fossils belong to a very ancient type of life. Slates nearly of the same age are those of Georgia in Vermont, which contains the *Olenus*, *Olenellus*, *Conocoryphe*, etc., and of eastern New York. These were claimed by Dr. Emmons, in connection with various limestones, quartzites, and schists, to belong to a group lower than the Potsdam sandstone, to which he applied the name of *Taconic* system. After thirty years of discussion, it seems to be agreed that both the advocates and opponents of the Taconic system possessed points of truth and error, since the Olenus slates must go below the Potsdam, while the limestones and slates belong to the Cambro-Silurian.

The Primal slates of Pennsylvania and Virginia seem to be Cambrian.

By far the best known of the Cambrian rocks is the Potsdam sandstone, which for so long a time was thought to be the oldest fossiliferous rock in the country. It seems to have been an ancient beach skirting the land all through the later Cambrian ocean. From the mouth of the St. Lawrence to the large range of the Rocky Mountains, this sandy band is easily recognized, commonly as a shore deposit, though a limestone is at its eastern outcrop at Anse Au Loup. The trilobites *Conocoryphe*, *Dicellocephalus*, are characteristic of this life, with many *Lingulæ*. This ancient beach follows the Appalachian range in the east, as it does the Rocky Mountains in the west. It skirts the west base of the Green Mountains, and nearly encircles the Adirondacks. One branch from here follows down the north shore of the St. Lawrence the entire distance, while the other can be traced to Minnesota. Other interesting localities are in Missouri and Texas, where they encircle the Laurentian islands. The older slates, carrying *Olenus* and *Paradoxides*, are not usually found in their proper topographical place in the earth, between the Potsdam and Eozoic, and hence the Cambrian band about the Adirondacks and Laurentian mountains is quite narrow.

The Cambro-Silurian commences with the calciferous sandrock of New York, or the auroral series of Pennsylvania. The animals are entirely different from those of the preceding period. The plants are sea-weeds in both, and very few in number. The Cystidians, a class related to Crinoids, culminated in this period, and the Orthoceras, a straight shell allied to the Nautilus, attained a length of twelve feet. These Orthoceras were the sharks of this ancient ocean.

The name applied to this division in New York is that of Champlain. It is very widely distributed, overlying the Eozoic very generally, even where the Cambrian series is wanting. An