SCIENCE

FRIDAY, APRIL 13, 1900.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor, J. McKeen Cattell, Garrison-on-Hudson, N. Y.

*THE GEOLOGICAL AND FAUNAL RELATIONS OF EUROPE AND AMERICA DURING THE TERTIARY PERIOD AND THE THEORY OF THE SUCCESSIVE INVASIONS OF AN AFRICAN FAUNA.**

SEVERAL years ago the discovery of some new types of Rhinoceroses in this country directed my attention afresh to the study of the Tertiary fauna of Europe as parallel with that of America. In the succession of European and American types it appeared that there were most interesting similarities between rhinoceroses as widely separated as the present regions of Colorado and Southern France, but upon attempting more than a general comparison I was confronted by a lack of definite time scale between the levels in which these animals occur. The available correlations by Cope, Filhol, Scott, Zittel and others proved too indefinite at certain points. This difficulty became so obstructive that a more exact correlation of European and American horizons appeared to be an essential basis not only for the phylogeny of the Rhinoceroses but for that of other types of mammals of Europe and North America.

STRATIGRAPHICAL CORRELATION.

In an address before the Academy last year the various steps which have been taken to secure such correlation were described. The work proves to be a very diffi-

*Address of retiring President, New York Academy of Sciences, February 26, 1900.

cult one and is by no means complete. The kind co-operation of the leading paleontologists of Europe was enlisted and as a result an approximate correlation sheet was prepared. This was virtually a report of progress in this investigation, main emphasis being laid upon geological succession. In continuing the subject this year, main emphasis will be laid upon *faunal* succession or the distribution of the different orders and families of mammals, concluding with the latest views as to the succession of life during the Pleistocene period in Europe.

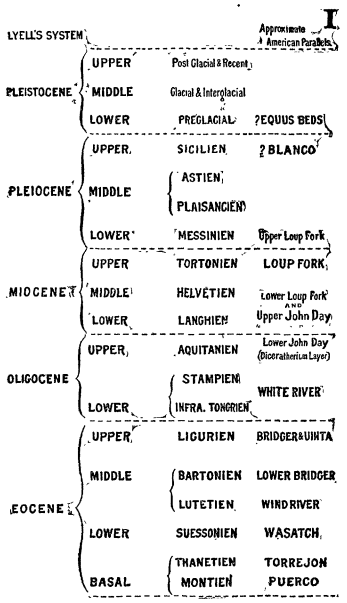

CHART I.—Preliminary Correlation Table of European and American Tertiary Horizons. On all the levels above the Stampien the parallels are imperfectly established.

The preliminary correlation sheet abbreviated in Chart I. sets forth the results of the geological succession and correlation so far as it has been carried at present and illustrates the rapid progress of our knowledge of our own horizons. It includes the latest results of the American Museum explorations in the Miocene of Colorado and Kansas, as roughly studied by Matthew, but these correlations are not to be understood as final. Scott has already transferred our John Day of Oregon, from the Miocene, where it was formerly placed, to the Upper Oligocene. The lower part at least of these beds belongs in the Oligocene —while the Upper John Day may prove to correspond with the Lower Miocene of Europe. Our Pliocene record as compared with the magnificent Pliocene of Europe is extremely meagre and our Miocene succession rich as it is, is not as fully understood as the Miocene of France. We look for more exact results from the American Museum explorations which are now being collated. It is only when we pass into the great time period from the Oligocene downwards that the American record becomes a superbly complete time standard for the whole Northern Hemisphere or Holarctic Region.

TERTIARY GEOGRAPHICAL DISTRIBUTION.

The importance of geographical distribution was first recognized by Humboldt, and set forth by Darwin in the 'Origin of Species,' in 1858. In the same year Sclater divided the world into eastern and western divisions or Palaeogæa and Neogæa, to embrace the Old and New Worlds respectively, a division which has proved to be totally illogical. This led Darwin's distinguished colleague, Alfred Wallace, to his great work upon the 'Geographical Distribution of Animals' and the division of the world into life regions; in which Sclater's scheme was adopted and developed.* In 1868, Huxley divided the world into a northern division, Arctogæa, and a southern division Notogæa to include the Northern and Southern Hemispheres respectively; this division was a little nearer the truth than Sclater's. Between 1868 and 1890,

* The history of opinion upon this subject is fully set forth by Lydekker's invaluable work the 'Geographical Distribution of Mammals,' published in 1896.

Sclater, Allen, Newton and Blanford, working upon living birds and mammals, continued this investigation, but it remained for Blanford, in 1890, to prove that the world zoologically should be divided into three great divisions; an Australian, a South American and a third region, Arctogæa, comprising North America, Europe, Asia and Africa.

Now it is clear that exactly as our understanding of the relations of living animals and plants to each other depends upon their fossil ancestors or upon their paleontology, so the final test of a scheme of zoological distribution must be a paleontological test. The animals of various families and orders have either originated in or migrated into their present habitat in past time, so that the geological record as to their order of appearance becomes of first importance. Here again the necessity of an *absolutely reliable correlation time scale* such as we are now establishing becomes evident, for the very first step toward an exact solution of the problem of past migration is to establish, as far as possible, the faunal parallels upon different continents, we can then determine where certain types of animals first appeared, and distinguish between the autocthonous endemic or native types and the migrant or new types.

This then is our problem, to connect living distribution with distribution in past time and to propose a system which will be in harmony with both sets of facts.

The tests of synchronism between European and American depositions are fourfold: First, the presence of a number of identical or closely allied genera and species. Second, similarity in the steps of evolution in related animals. Third, the predominance and spread of certain animals, as of the odd-toed Ungulates in the middle Eocene and of the even-toed Ungulates in the Upper Eocene. Fourth, the sudden appearance of new types which have apparently originated elsewhere and have enjoyed an extensive migration, so that they appear simultaneously in different regions of the earth. An instance of this kind is afforded by the unheralded appearance of new types in the base of the Oligocene (Rhinoceroses) and of the Miocene (Proboscidia) in Europe and America.

Unfortunately there is still no agreement among zoologists as to the faunal geographical divisions. Lydekker, well versed in both paleontology and zoology, has for the first time brought together both classes of evidence in his recent valuable work upon the 'Geographical Distribution of Mammals'; he shows conclusively that zoopaleontology favors the division of the world into three great realms as proposed by Blanford, to these may be applied the terms Arctogæa, Notogæa and Neogæa, as proposed anonymously in 1893. (Chart II.)

Geographically, these realms are connected by low lying portions of the earth, which, during long periods of submergence beneath the sea, have completely isolated them. At the same time we are forced to conclude that there were shorter intervals of elevation or land continuity at various times during the Tertiary period.

Now it is a well-known principle of zoological evolution that an isolated region, if large and sufficiently varied in its topography, soil, climate and vegetation, will give rise to a diversified fauna according to the *law of adaptive radiation* * from primitive and central types. Branches will spring off in all directions to take advantage of every possible opportunity of securing food. The modifications which animals undergo in this adaptive radiation are largely of mechanical nature, they are lim-

*So termed by the writer, see 'Rise of Mammalia in North America,' 1893, and 'Origin of Mammals,' 1898.

ited in number and kind by hereditary, stirp or germinal influences, and thus result in the independent evolution of similar types in widely-separated regions under the *law of parallelism or homoplasy.*

This law causes the independent origin not only of similar genera but of similar families and even of our similar orders. Nature thus repeats herself upon a vast

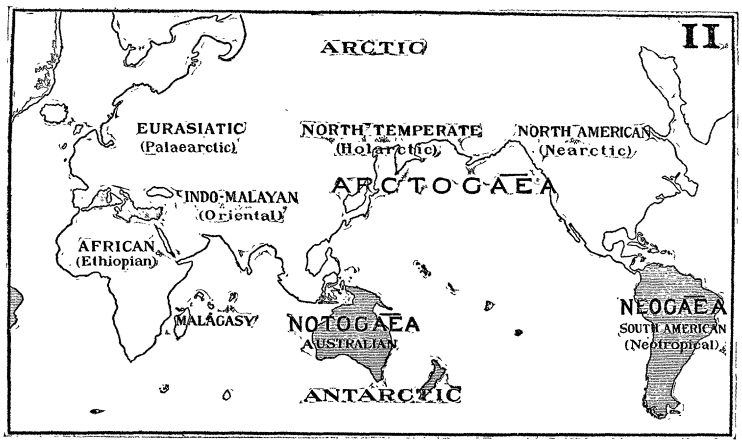

CHART II.—Division of the World into three Realms and nine main Geographical Regions. The continental platform is raised to the 200 metre line showing the main Tertiary land connections.

scale, but the similarity is never complete and exact. When migrations are favored by over-population or geographical changes, a new and severe test of fitness arises by the mingling and competition of the parallel types.

Now under the operation of these laws a most interesting generalization or hypothesis can be made as to the three realms, geographical isolation has been so continuous and prolonged that great orders of mammals have been evolved (Chart IV.) in each. Thus *Arctogæa* containing the broadest and most highly diversified land area, appears hypothetically as the center in which fourteen primitive and specialized orders radiated from each other. In the southern portion of *Neogæa*, at least four orders sprang from primitive members of the above orders, and the Hystricomorph rodents enjoyed their chief radiation. In *Notogæa* two orders were cut off by the sea, one of them a rapidly declining type, the Monotremes, the other the Marsupials enjoying a very highly diversified radiation. This hypothesis is expressed in Chart IV. Two other orders of mammals, the Sirenia (probably a branch of the hoofed tribe), took the rivers and coasts of America, Europe and probably Africa as their radiating center, while the Cetacea occupied the fourth or oceanic realm.

Now, we mean to express by this hypothesis that *Realms* were the main centers of *adaptive radiation of orders*, by no means the exclusive areas of distribution, for during the periods of land contact certain members of these orders found their way into adjacent realms. Each realm, therefore, contains its pure autocthonous types and its migrant or derived types. *Regions*, on the other hand, may be distinguished from realms as geographical and zoological areas, which have been isolated from each other for shorter periods, either by climatic barriers, as in the case of the Arctic or circumpolar region, or by great physical bar-

riers, such as masses of water and of desert sands. In certain cases these regions, such as Africa, appear to have been so large, distinct and isolated as to have become important centers of the radiation of certain *orders* of mammals, and almost attain the rank of realms, but regions in general are chiefly and permanently distinguished by the *adaptive radiation of families of mammals.*

Arctogæa may thus be still divided on the old lines into five or six regions, the *Arctic* or Circumpolar; the *Ethiopian* or African, south of the Sahara; the *Indo-Malayan* or Oriental, including southern Asia and the Malayan islands; the *Malagasy,* including Madagascar; the *Nearctic* and the *Palaearctic.* There is no question, as suggested by Professor Newton in his term 'Holarctic,' and by Professor Allen in 1892, in his term 'North temperate,' that the North American (Nearctic) and Eurasiatic (Palaearctic) regions are now so closely similar that they might be united into one. When, however, the zoological or existing characteristics of these regions are put to a paleontological test it is found necessary to separate them, because throughout the Tertiary period North America and Eurasia were so remote that, to a certain extent, they constituted centers, not only of independent family, but to a limited degree of ordinal radiation. At the same time they were unified, both by frequent intermigrations and by a simultaneous evolution of allied animals.

We now come to one of the greatest triumphs of recent biological investigation, namely, the concurrence of botanical, zoological and paleontological testimony in the reconstruction of a great southern continent to which the name Antarctica has been given. Following Blanford (1890), in 1893 Forbes* made the first strong plea for this continent. The flood of evidence for the Antarctica theory has now become so strong that only a few details can be mentioned: Forbes (1893) and Milne-Edwards from the consideration of the birds; Beddard (1895) from the study of worms and other invertebrates; Moore (1899) from the study of the flora of South Africa; Spencer (1896) from the study of the fauna of Australia; Ameghino, Hatcher, and Ortmann from studies and collections of vertebrate and invertebrate fossils in Patagonia not yet fully published; Moreno (1899) from the discovery of Miolania, an Australian fossil reptile recently found in South America. From these and many other sources has been brought forth the body of testimony which draws us almost irresistibly* to the conclusion that there was an Antarctic continent at various times connecting South America, South Africa, Australia and New Zealand. Such a connection strengthens Huxley's conception announced in 1868, that the zoological regions were mainly upon lines of latitude, rather than as suggested by the present configuration of the earth, upon lines of longitude. With the theoretical elevation of this submerged continent (Chart III.) which may be called the 'Antarctic Region,' so as to connect the southern land masses at various times, all present and past geographical distribution may be theoretically accounted for. Elevation to the 10,000 foot (3040 meter) line still leaves a broad channel south of Africa. Without such elevation we are still met by many insuperable difficulties.

Among other problems, a land connection between Africa and South America across the South Atlantic enables us to explain the remarkable distribution of the sirenia, sea-cows, dugongs and manatees, now found exclusively in the tropical belt of Africa and the Americas. (See Sirenia, Chart

* H. O. Forbes, *Geographical Journal,* 1893. Also *Natural Science,* 1893, p. 54.

* After discussing the evidence with great fairness Lydekker (1896) takes a more conservative position.

IV.) These animals first appear in the oligocene of Germany. It is also, of course, possible that they may have taken a northern route as indicated by the remains of *Rhytina* in the North Pacific.

Dr. Louis Dollo, of Brussels, has recently endeavored to demonstrate that all *Marsupials* have been evolved from arboreal forms like the Opossum.* If we can draw a parallel with the adaptive radiation of the

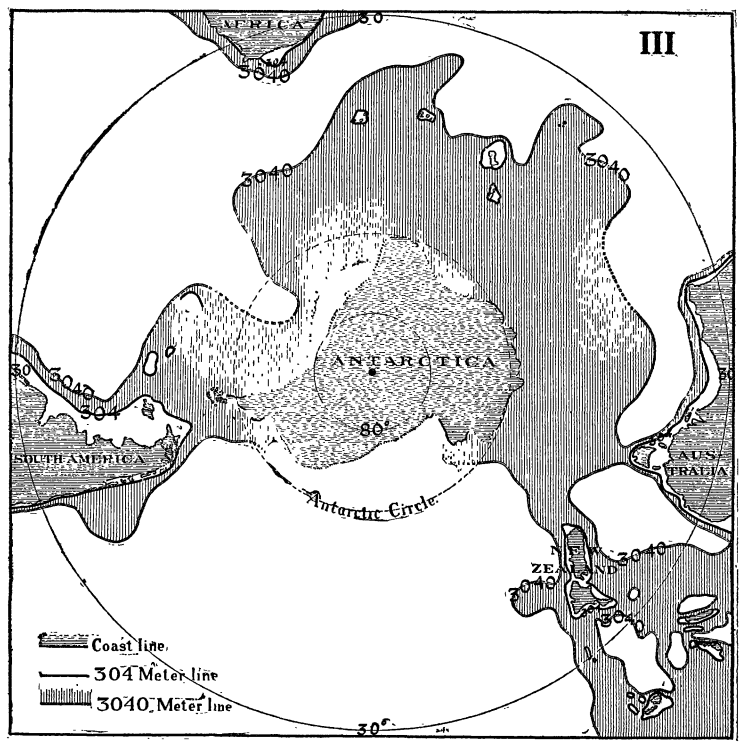

CHART III.—Restoration of Antarctica by elevation to the 3040 sounding line, showing old continental lines and greater depth between Africa and Antarctica.

Before confining our attention to *Arctogæa*, let us further consider the mesozoic relations of the three realms. (Chart I. and Chart II.)

In the Jurassic period stem forms of Insectivores, Marsupials and possibly of Monotremes* are found in Arctogæa and seem to establish the theory of northward origin of the mammalia as a class.

* The writer's view (1888) that the Jurassic Mammals of England and Wyoming embrace primitive placentals or Insectivores as well as Marsupials and Multituberculates (? Monotremes) is now generally accepted.

placentals during the 3,000,000 years, more or less, of the Tertiary, we may safely conclude that such a primitive family, entering the Australian region during the Cretaceous period either by way of Antarctica (Spencer) or by way of the Oriental region (Wallace and Lydekker), might have peopled Australia with all its wonderfully diversified forms of Marsupial life. The Didelphyidæ are to the Marsupials what the Creodonts are to the placentals in point of potential

* Les Ancêtres des Marsupiaux étaient-ils arboricoles? Miscellanées Biologiques, Paris, 1899.

evolution. The *Monotremes* also may have entered NOTOGÆA by either of these routes.

North America is the only part of the globe where Cretaceous mammals are known at present. In the late Cretaceous we appear to discover evidence of the existence of the following orders: Insectivora, Creodonta or ancestral Carnivores, hoofed animals or Amblypoda and perhaps the earliest Monkeys or Mesodonta. In the basal Eocene we certainly find primitive Monkeys or Mesodonta; Rodentia and Tæniodonta or ancestral Edentata. A land connection with South America in the early Eocene would therefore have supplied *Neogæa* with the Edentates as well as the stem forms from which might have been derived its wonderful radiation of hoofed animals—the Litopterna, Typotheria and Toxodontia; together with the remarkable radiation of the Hystricomorph or porcupine-like rodents and of two families of Monkeys.

The exact zoological affinities of the oldest mammalian or *Pyrotherium* fauna of South America remain to be determined. *Pyrotherium* itself is considered by Ameghino (1895) as the source of the order PROBOSCIDIA while other ungulates are believed to be related to the HYRACOIDEA, upon the affinities of these forms turns the problem whether South America derived the sources of its great radiation from Africa or from South America. (See Chart IV.)

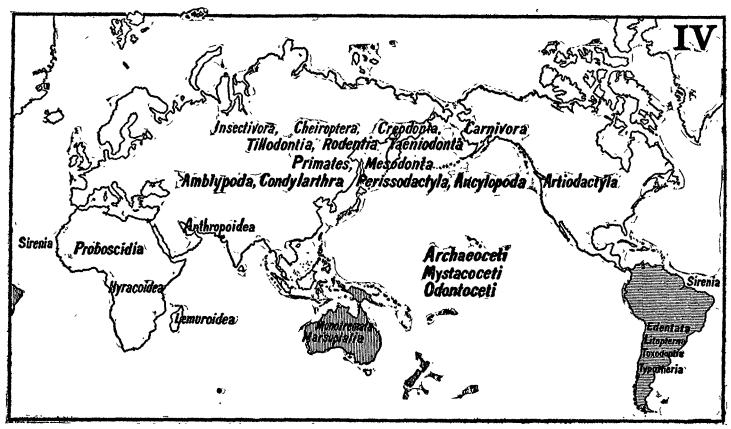

CHART IV.—Order of Mammals placed in their hypothetical chief centers of adaptive radiation during the Tertiary Period.

Four streams of migration to and from NEOGÆA appear to have occurred; the first established its autochthonous fauna or distinctive radiation of peculiar ungulates and edentates. The second related this region with Africa, via Antarctica; this contact, in addition to the problematical Proboscidia and Hyracoidea above alluded to, apparently introduced stem forms of Edentates into the Ethiopian region from which were derived the Pangolins and Aard Varks; these peculiar edentates together with Armadillos all occur in southern France in the lower Oligocene (Fihol, 1893); this land bridge also distributed the Cape Golden moles, *Chrysochloridæ;* these facts and others too numerous to mention serve to show the vast importance of the explorations in Patagonia and make us impatient for the exact conclusions which are forthcoming from the materials brought together by Ameghino and Hatcher.

The third migration into Neogæa established its links with Australia, bringing in Marsupials, both polyprotodont and diprotodonts. The fourth was from the north, Arctogæa, and is positively known; it occurred at the end of the Miocene, and brought in the northern Carnivora, Bears, Wolves, Cats, and Sabre-tooth Tigers, Raccoons and Mustelines, the Artiodactyla, deer and camels, the Perissodactyla, horses and tapirs, three types of Rodents, the Squirrels, Mice and Hares or Rabbits and the Mastodon. The Notogæic types, as well as the animals of the first invasion, in the meantime had largely died out, and the introduction of more vigorous Arctogæic types, especially the carnivores, together with a change of climate, exterminated a further portion of the autochthonous Neogæic fauna. At the same time, that is of this second invasion, many of the South American forms entered North America; they seem to have reached this continent in the upper Pliocene.

We now turn to Arctogæa. In the Eocene period we find in Europe and North America what may be considered the pure or Autochthonous fauna of the Holarctic region, in the absence of all knowledge of Asia. Southern Asia is an absolute *terra incognita* the earliest known deposits in this region being in the Upper Oligocene in which the fauna is remarkably similar to that of Europe. Northern Asia is unknown paleontologically until the Pleistocene—here is a region for explorers. However, we may consider it as part of a broad Eurasiatic land area—extending from the Rocky Mountain Region to Great Britain. The faunal relations are astonishingly close, between the new and old worlds at this time. Every year's discovery increases the resemblance and diminishes the differences between Europe and the Rocky Mountain region. Distinguishing North America, however, are the Tylopoda, this sub-order includes the peculiar Artiodactyla of the Camel-llama tribe; these Professor Scott in a recent paper considers as including all the early types of American ruminants which we have been vainly endeavoring to compare with European types. The radiation of the Tylopod phylum into a great variety of types is quite conceivable and it is thoroughly consistent with the fundamental law of adaptive radiation which we find operating over and over again.

In Europe there are in the upper Eocene two classes of animals, first those which have their ancestors in the older rocks. The second class includes certain highly specialized animals which have no ancestors in the older rocks—among these, perhaps, are the peculiar flying rodents or *Anomaluridæ*, now confined to Africa, and secondly the highly specialized even-toed ruminant types—the Anoplotheres, Xiphodonts and others, the discovery of which in the *Gypse* near Paris—Cuvier has made famous. It is tempting to imagine that these animals did not evolve in Europe but that they represent what may be called the first invasion of Europe by African types from the Ethiopian region.

It is a curious fact that the African continent as a great theater of adaptive radiation of Mammalia has not been sufficiently considered. It is true that it is the dark continent of paleontology for it has practically no fossil mammal history but it by no means follows that the Mammalia did not enjoy an extensive evolution there.

Although it is quite probable that this idea has been advanced before—most writers speak mainly or exclusively of *the invasion of Africa by European types.* Blanford and Allen it is true have especially dwelt upon the likeness of the Oriental and Ethiopian fauna but not in connection with its antecedent cause. This cause I believe to have been mainly an invasion from south to north correlated with the northern ex-

tension of Ethiopian climate and flora during the Middle Tertiary. It is in a less measure due to a migration from north to south. Let us therefore clearly set forth the hypothesis of *the Ethiopian region, or South Africa, as a great center of independent evolution* and as the source of successive northward migrations of animals, some of which ultimately reached even the extremity of South America—I refer to the Mastodons. This hypothesis is clearly implied if not stated by Blanford in 1876 in his paper upon the African element in the fauna of India.

The first of these migrations we may suppose brought in certain highly specialized ruminants of the upper Eocene, the Anomalures or peculiar flying rodents of Africa; with this invasion may have come the Pangolins and Aard varks, and possibly certain Armadillos, *Dasypodidæ*, if M. Filhol's identification of *Necrodasypus* is correct. A second invasion of great distinctness may be that which marks the beginning of the Miocene when the Mastodons and Dinotheres first appear in Europe, also the earliest of the Antelopes. A third invasion may be represented in the base of the Pliocene by the increasing number of Antelopes, the great giraffes of the Ægean plateau, and in the upper Pliocene by the Hippopotami. With these forms came the rhinoceroses with no incisor or cutting teeth, similar to the smaller African Rhinoceros, *R. bicormis*. Another recently discovered African immigrant upon the Island of Samos in the Ægean plateau is *Pliohyrax* or *Leptodon*, a very large member of the Hyracoidea, probably aquatic in its habits, indicating that this order (popularly known as the conies) enjoyed an extensive adaptive radiation in Tertiary times.

It thus appears that the Proboscidia, Hyracoidea, certain edentata, the Antelopes, the Giraffes, the Hippopotami, the most specialized ruminants and among the rodents, the Anomalures, the Dormice, the Jerboas and among Monkeys the Baboons may have enjoyed their original adaptive radiation in Africa—that they survived after the glacial period, only in the Oriental or Indo-Malayan region, and that this accounts for the marked community of fauna between this region and the Ethiopian as observed by Blanford and Allen.

Against the prevalent theory of Oriental origin of these animals is: first, the fact observed by Blanford and Lydekker in the Bugti Beds (Sind) that the Oligocene or lower Miocene fauna of the Orient is markedly European in type; second, that if these animals had originated in Asia some of them would have found their way to North America; third, the fact that all these animals appear suddenly and without any known ancestors in older geological formations. These are the main facts in favor of the Ethiopian migration hypothesis.

In the meantime the unification of the North American and Eurasiatic regions was proceeding by intermigration. In the lower Oligocene the giant pigs or elotheres, the Tapirs and peculiar amphibious rhinoceroses, known as Amynodons, found their way from America to Europe, while Europe supplied us with a few Anthracotheres, both Anthracotherium and Hyopotamus. In the Miocene Europe sent us the true Cats and we supplied Europe with the destructive sabre tooth tigers; in the upper Miocene Europe sent us our first deer and cattle or *Cervidæ* and *Bovidæ*, also probably the Mastodons *en route* from Africa. In the Pliocene we supplied Europe with the rabbits and hares, and possibly with the raccoons, if the Panda belongs to this family. In the Pleistocene the Camels wandered into Asia from America, while the Bears passed them *en route* to America. These are a few instances out of many which are already well known.

On the other hand certain families had an

exclusively Eurasiatic history, so far as we know. These are, among animals related to the horse and tapir, the Palæotheres and Lophiodon; among ruminants the Traguline deer and Muntjacs; among insectivores the hedgehogs; among primates, the Anthropoid Apes and the lemurs. The latter are peculiar to the Malagasy and Ethiopian regions. At the same time America exclusively raised the Titanotheres,* the *Hyracodontidæ* or cursorial rhinoceroses, the pouched rodents or *Geomyidæ*, all the early families of Tylopoda, the peccaries. It is paradoxical that so many animals which we are wont to consider typically American came from the Eurasiatic region, while so many others which we always associate with Asia and Africa came from this country. Herein lies the necessity of a paleontological basis for zoogeography.

PLEISTOCENE DIVISIONS IN EUROPE.

The Pleistocene Quaternary or Glacial Age is the period in which the present distribution of animals and plants was determined. In this period the fulness of European investigation is in strongest contrast with the indecisive results of American work and in no other period can we anticipate more weighty inductions from Holarctic correlation. It is especially important to determine the relative antiquity of the first recorded traces of man in the two continents.

It is true the Pleistocene history of Europe is still in a formative stage, but it is absolutely evident that a final and positive time scale and subdivision of the early Age of Man is not far distant and that the vast labors of geologists, botanists, zoologists, paleontologists and anthropologists will be rewarded with a harmonious theory of all its phenomena.

Combined attack by geological and biological methods has nowhere produced more brilliant results. The unaided testimony of the rocks and soils fails to tell us of the successive advances and retreats of the ice but where, owing to the obliteration of surface deposits, geology is in confusion, plant and animal life serves both biology and meteorology like a vast thermometer actually recording within a few degrees the repeated rise and fall of temperature. This record consists of the invading and retreating life waves of river, forest, field, barren ground, steppe, tundra and arctic types, with increasing cold, or the reversed order, with diminishing cold, in the same localities or geographical areas. There seems to be sufficient evidence for a main division of the Pleistocene as follows:

Upper Pleistocene =		*Postglacial.*
Middle Pleistocene	Upper, Middle, Lower	*Glacial.*
Lower Pleistocene =		*Preglacial.*

Briefly the prevailing views in Europe as to the glacial age are told in Chart V.

(1) The preglacial stage presents a mingling of south temperate, temperate and northern forms of mammals.

(2) The long first glacial advance was followed (Pohlig) by the Rixdorf stage, intermorainal, colder than the succeeding Mosbach and Thuringian stages which have a more temperate facies in the recurrence of some of the Forest Bed Fauna.

(3) The faunal evidence for a colder mid-glacial period is conclusive. The evidence for a second or mid-glacial advance, between the first and last great glacial stages, is mainly biological, that is, subarctic are followed by more temperate life forms, as we gather largely from studies of the rodent fauna by Nehring, Studer and others. The hypothesis of three distinct glacial advances and of two inter-glacial retreats rests therefore upon a combination of geological and biological evidence which is not as yet conclusive.

* A Titanothere is reported in Roumania.

(4) There followed the postglacial, neolithic, alluvial stage.

Geographically the beginning of the Pleistocene is remarkable for its *broad land connections* and it represents the last stage of that community of fauna which during the Pliocene distinguished the entire region of Europe, Asia, Africa and North America. These connections may all be restored by raising the continents to the 200-meter or 100-fathom line as shown in Chart II. The mid-Pleistocene period in Europe is mainly one of *continental depression;* (1) at the climax of the first glacial advance extensive portions of northern Europe were submerged beneath the sea, (2) at the close of the first interglacial or temperate period (*Elephas antiquus* stage, Pohlig) occurred

CHART V.

PARTLY THEORETICAL DIVISIONS OF EUROPEAN PLEISTOCENE, AFTER POHLIG, DEPÉRET, NEHRING AND OTHERS.

I. Main Stages.	II. Partly Theoretical Relations of Glacial Oscillations.	III. Characteristic Geological Deposits.	IV. Faunal Div. (Pohlig.) Localities. Climate. Gen. Fauna. Stratigraphical Faunal and Geological Succession.	V. Human Remains and Characteristic Mammals.
Neolithic implements.	Recession of Glaciers.	Humus, Lake Terraces. Post-Glac. Löss.	**Prehistoric Stage.** N. temperate. Forest, Upland, River and Field Fauna.	**Forest and Lake Dwellers.** Recently exterminated types.
UPPER PLEISTOCENE. Post-Glacial or Alluvial.				
	3d Glacial.		**Elephas primigenius stage.** N. Temperate and Boreal, Steppe and Forest Fauna.	**Neanderthal and Spy, human types. Steppe and Cave Dwellers.**
		Löss, Valley Gravels, Cave Clays, Diluvium, Sands.		
(Moustiéren Human type.)	2d Interglacial.		Up. Rodent, Steppe Fauna, Yellow Culture Layer; Lower Rodent Tundre Fauna.	Felis, Hyæna, Ursus spelæus, Cyon alpinus, Capra ibex, Ovibos, Rangifer, Bison priscus, Equus, R. tichorhinus, Elasmotherium, Elephas primigenius.
Palæolithic implements.	2d Glacial.		Subarctic Tundre Fauna.	
			RHINOCEROS MERCKII.	
MIDDLE PLEISTOCENE. Glacial or Diluvial.	Interglacial.		**Elephas antiquus stage.** N. Temperate Thuringian tufa, Taubach (Weimar)	**Oldest human remains known, Molar teeth** (Nehring). Saiga prisca, Alces machlis, Capreolus, Lemmus, Alactaga saliens, Lepus, Elephas antiquus, E. primigenius. Rhinoceros merckii.
(Chelléan Human type.)	1st Interglacial.			
		Fluviatile, River Sands, and Gravels.	**Elephas trogontherii** Temperate. B. Mosbach Sands (Lower Terraces).	Felis spelæa, F. lynx. Bison, Sus scrofa, Cervus elaphus, Equus caballus, Rangifer, Hippopotamus, Arctomys.
		Gravels, Conglomerates, Sands.	A. Rixdorf Beds, Subarctic.	Megaceros, Ovibos, R. tichorhinus, R. merckii, Elephas trogontherii.
	1st Glacial.	Boulders. Erratics, Clays, Drift, Sea-terraces, Moraines.	Arctic.	Fauna unknown.
LOWER PLEISTOCENE. Preglacial or Transitional to Pliocene.	Advance of Glaciers.	Estuarine and Fluviatile, Marls and Sands.	**Elephas meridionalis stage.** Forest Beds (Norfolk). St. Prest. Durfort. Malbattu (Auvergne Puy de Dome). Chalon - St. Cosme (Bresse).	**Earliest palæoliths.** Machærodus, Hyæna spelæa, Ursus spelæus, Lutra, Ovibos, Hippopotamus, Bos primigenius, Equus stenonis, Rhinoceros etruscus, Elephas meridionalis, E. antiquus, Trogontherium.

the volcanic disturbances in Central Europe and the hot spring formation of Thuringia (Taubach, Weimar); at this time *all the old continental connections characteristic of the Tertiary and serving as land bridges for free Holarctic Oriental and Ethiopian migration began to break up in the following manner.* During the early mid-Pleistocene or *Elephas antiquus* stage (Pohlig) the English channel broke through the long pre-existing land-bridge between England and France; Great Britain was faunally isolated; similarly the Irish Channel was depressed and Ireland (Scharff, 1894) lost its land connection with Wales in the early Pleistocene and with Scotland in the newer Pleistocene. In the Mediterranean region, also, at the close of the first interglacial period (Pohlig), the land-bridge across Gibraltar, also that between Italy, Sicily and Africa was broken; Malta was isolated as an island and the great *Elephas antiquus* dwindled into the small insular type *E. melitensis.* To the eastward the Mediterranean Sea extended over the Ægean plateau, which had previously been terra firma, and the new Ægean Sea cut off the land connection between Greece and Asia Minor.

I. *Preglacial. Elephas meridionalis Period.*

The typical preglacial deposits are the *Forest Beds* of Norfolk, England. The weight of opinion and of fact is all upon the side of considering these beds as Pleistocene. From the lists given by Dawkins, Schlosser and other writers, the Preglacial period is found to contain:

12 Pliocene species.
32 Pleistocene species and races, now extinct.
17 Living species, of which 7 are Insectivora and Cheiroptera.

The most remarkable feature of this fauna is the mixture of African and North Asiatic forms. The great *Elephas meridionalis* a precursor of the Mammoth, is the most characteristic type. The first traces of man in the paleolithic flints of the Chéleen type occur upon this level.

The climate, judging by the flora and Conchylien fauna, was somewhat cooler than that of the upper Pliocene. The first arctic flora in England is in a layer which separates the *Forest Bed* from the glacial Boulder Clays. To this period, according to most authorities, the *Pithecanthropos erectus* of Dubois belongs. Others, including the late Professor Marsh, consider this link between man and apes, of Pliocene age.

II. *Glacial and Interglacial, or Mid-Pleistocene.*

1. *Lower Mid-Pleistocene. Lower Stage.*—In climate the early part of this period, immediately during and succeeding the ice period, was very extreme. None of the first ice period fauna is known unless we except *Elephas (primigenius) trogontherii* or *E. intermedius* and the red deer, *Cervuselephas*, the latter being doubtfully recorded from the Boulder Clay of England. Here, in the Rixdorf beds, we find the first arctic and subarctic types of animals in central Europe.

Middle Stage.—This stage (Mosbach Sands, Essex) marks the recurrence of a *more temperate climate*, first observed by Lyell and Evans in England and abundantly known in Germany and France. Two only of the characteristic Pliocene species recur, the hippopotamus and straight-tusked elephant. These alone have been universally cited as evidence of a south temperate or even of a tropical climate, but the more numerous hardy types which are found in this stage constitute still stronger proofs of a north temperate climate.

Geologically the deposits are of fluviatile origin consisting of river sands and gravels containing *Hippopotamus*, *Rhinoceros merckii* and Mammoth. The great beaver, *Trogontherium cuvieri* makes its last appearance here. *Geographically* the southern continental depression has not begun and the Lower Pleistocene land bridges persisted.

The Mosbach and Essex fauna give the following percentages:

4 Pliocene species (including two living types).
7 Pleistocene species, now extinct.
16 Living species (including 2 Pliocene species).

The characteristic Pleistocene types which are first recorded in Mosbach are early varieties of the Irish, Red and Roe deer, the moose and the cave lion, *Felis spelæa*. Among the living species recorded for the first time or making their first appearance at this stage are the Reindeer, Boar, Horse, Lynx, Badger and Marmot.

Upper Stage.—According to Pohlig, the mid-Pleistocene proper, or succeeding stage, was characterized by volcanic disturbances in central Europe and by the deposition of gypsum and tufas. Probably these earth movements were connected with the marked geographical changes brought about by wide-spread depression of the continental borders and isolation, which the same author assigns to this period. The fauna, typically represented in the Thuringian tufas, indicates a cooler or north temperate climate.. *Elephas antiquus* is very abundant, making its last appearance north of Italy. The typical locality is the Thuringian tufa in which Pohlig records 61 species. Parallel with this is the Taubach, near Weimar fauna.

In 1895 Nehring reported from this level what he regarded as the *oldest human remains* thus far found in Europe, consisting of two very large molar teeth resembling in some respects those of the Chimpanzee; this man he considered of the Chéleen type. In the same year Newton described a human skeleton of Esquimaux type in the still older 'Higher Terraces' or Hippopotamus level of Kent, England. The antiquity of this skeleton is, however, rendered somewhat doubtful by the fact that the skull is of much newer type than those of Neanderthal and of Spy, and the evidence for its extreme paleolithic age is not considered absolutely conclusive.

The faunal list is provisionally analyzed as follow:

3 Pliocene species still living (Castor, Hyæna, Arvicola).
7 Pleistocene species, now extinct.
23 Living species (including living Pleistocene Northern types).

The number of recorded living species increases, there being a marked increase especially in the number of Reindeer. The most important new living types are: the steppe antelope, *Saiga prisca* (*tartarica*), the moose, *Alces machlis*, the lemming, *Myodes lemmus*, the Siberian jerboa, *Alactaga saliens*, the porcupine, *Hystrix*, the rabbit, *Lepus timidus*. These constitute a distinct invasion of north Asiatic forms to the southern steppes.

2. *Upper Mid-Pleistocene or Elephas primigenius Stage Pohlig.*—As we enter the next succeeding Loess and Cave Period of Central Europe, the main life stage of the mammoth, *Elephas primigenius*, the wooly rhinoceros, *Rhinoceros antiquitatis* or *tichorhinus*, and the reindeer *Rangifer tarandus*, we note the decline of the broad-nosed rhinoceros *Rhinoceros merckii* and the absence of the straight-tusked elephant *Elephas antiquus* in geological deposits which are chiefly diluvial gravels, and sand clays. These facts alone indicate a prolonged colder period, a north temperate or boreal climate. The fauna presents a great variety adapted to different degrees of temperature but decidedly of northern type. Other facts indicate that this colder period was initiated by a distinct advance of the ice followed by a gradual recession, namely, the occurrence of arctic and sub-arctic types succeeded by north temperate types, in a number of localities, typically near Schaffhausen. (Nehring, Steinmann, Schlosser.)

These successive northern faunas in single localities are typically as follows: 1. Tundre Fauna; 2. Steppe Fauna; 3. Forest Fauna.

Europe now included a most remarkable diversity of life of Asiatic, North Siberian, Oriental and African origin. The climate was cold and relatively dry. The Reindeer, first the barren ground then the woodland variety, increased rapidly in number during this period and constituted its most distinctive form, hence this is known as the Reindeer period.

This stage is famous for the skeletons of man, the man of Néanderthal and Spy, very primitive in the structure of the skull, the oldest human skeletal remains with the exception of the *Pithecanthropus* of Java.

III. *Upper Pleistocene. Postglacial.*

As above observed there is a difference of opinion as to the interglacial or postglacial age of the loess. All the North Siberian, Oriental and African types gradually disappear, the modern European forest and field fauna alone survives. There is some evidence that both the Mammoth and Reindeer lived for a time in this period, the latter being now confined to more northern Europe. The Irish deer, *Megaceros hibernicæ* the Reindeer, the bovidæ *Bos taurus*, *Bos longifrons*, and *Bos brachyceros*, are the characteristic ruminants. *Alces palmatus* is a postglacial Russian moose. The horse, *E. caballus*, of larger and smaller varieties was now domesticated and used for food. The carnivora, rodentia and insectivora were all of modern type.

The detailed comparison of the Pleistocene of Europe, America and Asia is still under way, and very important results may be expected from it. It will be equally serviceable to American anthropologists and paleontologists, for our own Pleistocene is far from being understood. The stages represented by our horse or *Equus Beds*, which are usually considered Lower Pleistocene, as well as of the Megalonyx and Cave Fauna of the East remain to be exactly fixed. Interest in this problem is greatly enhanced by the fact that we may at any moment discover the remains of man or of his ancestors associated with *Equus excelsus* and positively demonstrate the existence of man upon this continent at a period contemporaneous with his first appearance in Europe.

Henry Fairfield Osborn.

CRUISE OF THE ALBATROSS.

IV.

Mr. Agassiz's final letter to the U. S. Fish Commission on the voyage of the *Albatross* is dated Yokohama, Japan, March 5, 1900.

After coaling and refitting we left Suva on the 19th of December, and arrived at Funafuti on the 23d, stopping on the way at Nurakita, the southernmost of the Ellice Islands. I was, of course, greatly interested in my visit of Funafuti, where a boring had been made under the direction of a committee of the Royal Society, in charge of Professor David, of Sydney, after the first attempt under Professor Sollas had failed. The second boring reached a depth of more than 1100 feet. This is not the place to discuss the bearing of the work done at Funafuti, as beyond the fact of the depth reached we have as yet no final statement by the committee of the interpretation put upon the detailed examination of the core obtained, and now in the hands of Professor Judd and his assistants. In addition to the above-named islands, we also examined Nukufetau, another of the Ellice group.

After leaving Nukufetau we encountered nothing but bad weather, which put a stop to all our work until we arrived under the lee of Arorai, the southernmost of the Gilbert Islands. On our way to Tapateuea from there we steamed to Apamama and Maiana, which we examined, as well as Tarawa. We next examined Maraki, an atoll which is nearly closed with high