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ORDINARY GENERAL MEETING

WAS HELD IN THE ROOMS OF THE INSTITUTE, ON MONDAY, APRIL 6TH, 1908.

COLONEL C. E. YATE, C.M.G., C.S.I., IN THE CHAIR.

The Minutes of the previous Meeting were read and confirmed.

ELECTION :—Hamilton Bland, Esq., M.D., and the Reverend Edwin D. Kizer, were elected Associates.

The following paper was then read :—

THE AMERICAN FAUNA AND ITS ORIGIN.

By Professor J. LOGAN LOBLEY, F.G.S., F.R.G.S.

CONTENTS.

INTRODUCTION.

THE American continent with its vast north and south extension and its complete isolation by water from all other lands presents a field for the observation of animal life of the greatest possible interest.

In latitudinal extension America ranges through 130 degrees, from 75° N. to 55° S. latitude, a distance of 9,000 miles or more than the diameter of the globe, a much greater north and south extension than that of the entire Old World or eastern continent, with all its austral insular adjuncts. Thus it extends

from the Arctic regions through the North Temperate zone through the tropics and through the South Temperate zone far towards the Antarctic Circle. But in addition to the latitudinal extension of America, its far-reaching and strikingly different physical features with great range of hygroscopic characters over widely separated areas, all contribute to the variety of conditions giving great climatic diversity. Mountains extend continuously throughout the entire length, rising in some of their peaks to over 20,000 feet, and enclosing almost rainless areas, while low plains with innumerable rivers and streams give regions abounding with water and atmospheric humidity little above sea-level.

The range of climatic and physical conditions that affect animal life may therefore be said to be as great within the bounds of the American continent as in the whole world, for the superior elevation of the Himalayas over the Andes is above the altitude at which animal organisms live, since even the adventurous mountaineers who have recently ascended the Himalayas to over 23,000 feet could not continuously live on the summits they so arduously gained.

Were the American portion of the land area of the globe continuous with the other portions, there would be nothing remarkable in finding in the western, a diversity of animal life equal to that of the Eastern Hemisphere, nor would it be surprising to find all the types of the one represented in the other. But the interposition of water as separating seas is such a formidable barrier to the migration of land animals, that the subject of the fauna of America acquires therefrom additional interest both with regard to its present features and to the indications its consideration affords of past geographical conditions and geological changes.

America cannot, however, be regarded as a single zoo-geographical area, since zoologists have long been impressed by the great difference between the general character of the fauna of its southern and that of the fauna of its northern extension, and they have therefore regarded these two portions as distinct zoological provinces or regions. In accordance with this view, Dr. Sclater constituted them two of his six zoological regions of the globe. The southern part of America, but including the West Indian Islands, Central America, and the eastern and western parts of Mexico, was named the Neotropical region, and the whole of the remaining part of the continent, the Nearctic region.

The subject of the distribution of the American fauna and

its origin is so extensive, that it is necessary for me to limit myself in this paper to the vertebrate terrestrial fauna, that is, to the mammals, birds, reptiles and amphibians, and even with this limitation it will be requisite to omit details and confine myself to a general statement of the leading features of the subject and the conclusions to which they point.

So much zoological research and so much investigation of zoological distribution has been carried out during the last half century, and so voluminous has been the literature on these subjects that I venture to think the present time is not inappropriate for such a review as is here attempted. The works of Alfred Russell Wallace, Dr. Sclater, Andrew Murray, Lydekker, Scharff, the American palæontologists, Amhegino, Leidy, Cope, Marsh, Ortmann and Scott, the German authors Suess and Zeitell, and other authorities, contain such an abundance of material that they give to conclusions based thereon a character of approximate finality that could not be claimed for earlier generalisations.

Conspectus of the American Fauna.

When the fauna of America is looked at as a whole some striking features will be noted. Firstly, that not only is every one of the greater divisions of the animal kingdom, the subkingdoms and the classes, to use the simple old nomenclature, represented in the New World, but, with few exceptions, the orders also, for of the twenty-nine orders of living terrestrial vertebrata only four are wanting, and one of these, Proboscidia, was represented in quaternary times. And while this is so there is but one order peculiar to America, and this order is represented by only one species, the gipsy bird of Eastern Brazil, *Opisthocomus cristatus*.

This conspicuous general correspondence between the animals of the western and eastern hemispheres indicates the essential oneness of the animal life of the globe, and its common origin, and at once suggests the former existence of land connections where now there are separating seas.

Although this oneness or unity is the most commanding feature presented by a comprehensive view of the living fauna of America, there are diversities from the fauna of the Old World of no little interest and importance.

We are struck by the fact that the most conspicuous and abundant mammals of Europe, Asia and Africa, are entirely

absent from America, that the highest and the lowest are also absent, for there are no anthropoid apes and no monotremes; that Proboscidia is wanting and that Carnivora and Ungulata are but poorly represented. Excluding man, both the highest and the lowest of the Primates are absent, so that we look in vain for the lemurs as well as the higher apes. The great and widespread family of Equidæ is also absent, for neither horses nor asses are indigenous to any part of America. So, too, *Sus* or the common pig is wanting, and so also are our familiar oxen and sheep. Besides these the following well-known animals of the Old World are not to be found on the American continent:—

Camel.	Hare.	Rabbit.
Cat.	Hyæna.	Rat.
Elephant.	Leopard.	Rhinoceros.
Giraffe.	Lion.	Tiger.
Hedgehog.	Mouse.	
Hippopotamus.	Panther.	

Amongst the birds there are wanting in America, bird of paradise, bustard, emu, lyre bird, peacock, ostrich, pheasant, starling, vulture and gallus, or common barn-door fowl, and of reptiles, there are no vipers, land-lizards, gavials or chameleons.

Some of these Old World animals have, however, analogues which, if not specifically allied, have a generic or family relationship. Thus, the puma represents the lions and tigers; the bighorn, the sheep; the bison, the oxen; the llama, the camels; the peccary, the swine; the rhea, the ostriches and emus; and the condor of the Andes, the vulture of the Pyrenees.

On the other hand, there are genera indigenous to America which have no living representatives in the eastern hemisphere. The sloths, the armadillos and the ant-eaters of South America, are quite absent from the Old World, these animals constituting three families also that are confined to the western continent. A most noteworthy zoogeographical feature is the restriction of the humming-birds to America. These exquisitely beautiful little birds, of which no less than 390 species have been described, constitute the family Trochilidæ, and not one species of this family is found in any other part of the world.

When the fauna of America is more critically examined and compared with the fauna of the eastern hemisphere, many important and highly interesting differences are discovered.

Mammalia.

The order Primates, again excluding man, has no one family common to the Old World and the New, and the families Cebidæ and Hapalidæ of America are both platyrrhine or having broad nasal septa, and in this respect differ from all the Old World monkeys which are catarrhine. The latter, too, are all without prehensile tails which many of the American monkeys possess. The Hapalidæ, or marmosets, have neither prehensile tails nor opposable thumbs and, therefore, have not true hands.

Of the Cheiroptera, one family is peculiar to the New World. This is the Phillostomidæ, or the leaf-nosed bats. These, with the exception of one species in California, are confined to South America and include the blood-sucking vampire bats. The other families of this order, Vespertilionidæ and Noctilionidæ are well-known bats in all the six zoological regions.

Of the Insectivora, only three families out of nine are represented in America, and of one of these, Centelidæ, there are only two species which are confined to the West Indies. The Talpidæ, or moles, have six species in America, and the shrews, twenty-four species, but confined to the northern part or the Nearctic region.

The great order Carnivora contains one family, the Procyonidæ, which is exclusively American. The typical genus Procyon gives the well-known racoons, and there are three other genera. These comprise eight species in all and chiefly inhabit South America, though one ranges as far north as California. The Felidæ, so conspicuous in the Old World, is represented by only a few species of the genus *Felis*. The puma, *Felis concolor*, ranging through 110 degrees of latitude, has the greatest range of any carnivore. The other species include the jaguar, *Felis onca*, and four lynxes or wild cats, though they differ from the *Felis catus*, the wild cat of Europe. The Canidæ, comprising our dogs, wolves and foxes, is a family well represented by species of the genus *Canis* to be found in all parts of America from the extreme north to Patagonia. The wolves, *Canis lupus*, are not, however, in South America, being there replaced by jackals and foxes. One genus of Canidæ, *Icticyon*, or the bush dog, is quite peculiar to America, and is restricted to the Brazils and Guiana. World-wide though the Canidæ may be said to be, they are not in the West Indies. Mustelidæ, comprising the weasels, otters, badgers, skunks and gluttons, is a family largely represented in America both in the north and the south, though the badgers have but one

species in South America. The glutton or wolverine, *Gulo luscus*, is restricted to the cold regions of the north of both the Old and New World, but in America it comes as far south as Lake Superior. Of the Ursidæ or bears, the most abundant is the grizzly bear of the Rocky Mountains, *Ursus horribilis*, which is closely related to the common brown bear of Europe, while the spectacled bear, *Ursus ornatus*, is restricted to the Andes of South America. The great white bear, Thalassarctos, or polar bear, *Ursus maritimus*, is, of course, confined to the Arctic coasts of the continent.

Of the order Ungulata there is a somewhat remarkable representation in America. The three conspicuous ungulates of the Old World, the horse, the ass, and the pig, are wanting, and the sheep is only represented by the bighorn, *Ovis canadensis*, of the north-west mountains, while the tapirs have four out of six species in the Neotropical region. The reindeer, *Rangifer tarandus*, of America differs somewhat from the reindeer of the Palæarctic region, as was explained in my paper on the fauna of Europe, and it ranges further south. In Labrador, the caribou, as it is called, may be found in herds of thousands. The elk or moose deer, *Alces machlis*, ranges southwards from the Arctic coasts to 45° N. latitude. The Bovidæ are not at all represented in the Neotropical region, being confined to North America, where the bison until recently was in countless numbers on its great prairie lands.

The musk ox, *Ovibos moschatus*, partakes of the character of both the ox and the sheep of Europe, but it is confined to the barren grounds, or great desert regions of the extreme north of the continent bordering the Arctic coasts. The prongbuck, *Antilocarpa americana*, is also confined to North America, but to the more southern latitudes of the prairies. The mountain goat, *Haploceros montanus*, seems to be confined to the northern parts of California. The American ungulates of the family Camelidæ are the llamas and the alpacas that form the four species of the genus *Auchenia*. These are entirely confined to South America.

The rodents, which number as many as 159 genera and 1,400 species, are largely represented in America, and no less than five families of the order Rodentia are not to be found in any other part of the world. These are the pouched rats, the haploodons, the chinchillas, the arboreal porcupines, and the guinea-pigs. The very widespread and well known family of Muridæ, with 87 genera and 730 species of rats and mice and their congeners, has many genera well represented in America, both

in the south and the north, and yet the typical genus Mus, or true mice and rats, with 130 species, including our own common house mouse, *Mus musculus*, and the brown rat, so abundant in London, is not to be found represented by a single indigenous species in either North or South America. On the other hand, the musk rat, *Fiber zibethicus*, and the genus *Heteromys*, are confined to the western continent. The jerboas or jumping mice have one species in North America, and one of the two species of beaver, *Castor canadensis*, ranges from Labrador to Mexico. The squirrels have in all 239 species. Of these twelve are in South and 82 in North America, but our lively little friend, the English squirrel, *Sciurus vulgaris*, is absent from both. The prairie-dogs, as they are called, *Cynomys ludavicianus*, are altogether American, but the true marmots, *Arctomys*, are both in America and Europe. Of Leporidæ, hares and rabbits, sixty-one species have been described, and of these twenty-five are American, but only one is in South America. The common hare of England, the mountain hare of Ireland and Europe, and the European rabbit are all three absent from America. A species of the picas or tailless hares, *Lagomys*, is found in the Rocky Mountains, and the coypu, a large beaver-like water rat, *Myopotamus coypu*, is well known in Peru and Chili. The family of rodents called Octodontidæ has sixty-eight species in the Neotropical region, and of these twenty-nine are peculiar to the West Indies.

The order Edentata has three families out of five in America, but all the three, comprising thirty-four species, are confined to Southern and Central America, or the Neotropical region. They are some of the most characteristic American animals. The sloths, forming the Bradypodidæ, and the ant-eaters forming the Myrmecophagidæ are arboreal, and inhabit the great forests of South America, but the armadillos, forming the Dasypodidæ, range throughout the Neotropical region.

The marsupials have a remarkable distribution, since they are confined to the Australian region and America, and of the thirty-nine genera comprising the order only two are to be found in America. These are Didelphys, with twenty-five species of opossums, and Chironectes, the water opossum. All except one species, *Didelphys californica* which is in Mexico and California, are inhabitants of the Neotropical region.

The lowest order of Mammalia, Monotremata, is altogether absent from the American continent, as it is from all the other zoogeographical regions except Australia.

Aves or Birds.

The Avian Fauna of America is conspicuously large and varied, much of it displaying vividly coloured plumage. Forests of vast extent in low-lying tropical regions are the habitats of innumerable species of insects, and so abundant food is provided for birds while uplands, hills, and mountains rising above the snow-line favour both the abundance and the richly varied bird-life of America.

Of the order Passeres, which includes sparrow-like and perching birds, and comprises nearly 6,000 species, a larger number than any other order of birds, there are twenty-eight out of fifty-one families represented in America, and of these fourteen are peculiar to the New World, while twenty-three Old World families of Passeres are absent from America. Dr. Russell Wallace estimates the number of species of Passeres in the Neotropical region at no less than 1,900.

The order Picariæ, including such birds as woodpeckers, kingfishers, and many richly plumaged birds, is especially conspicuous in America, to which seven of its twenty-five families are confined. Certainly the most remarkable feature of American ornithology is that afforded by the 390 species of one of the families of Picariæ, the Trochilidæ or humming birds. This highly differentiated family of small birds with refulgent plumage, as has been before noted, is entirely confined to the New World and almost restricted to the Neotropical region, for the Nearctic region gives only six of the 390 species. In Central America there are 100 species, fifteen in the West Indies and 290 species in South America proper.

Parrots, macaws and the like, forming the order Psittaci, are almost confined to the tropics, and in the Neotropical region are two families of Psittaci, Conuridæ and Psittacidæ, giving 141 species.

The Conuridæ are exclusively American, and one species ranges as far southwards as the Straits of Magellan, and another ranges northwards into the United States.

The order Columbæ, or pigeons, has in America about eighty species, chiefly inhabiting the Neotropical region. These birds are relatively less abundant in America than in the Australian region, and appear to favour islands rather than continents.

The Gallinæ, poultry and game birds, are well represented in the New World, although the type genus Gallus, our common fowl, is wanting, as are also the peacock and sand grouse, while the turkey, *Meleagris*, is an essentially American bird.

The order Opisthocomi has been constituted to contain the *Opisthocomus cristatus* which cannot be placed in any other family, and is exclusively American, inhabiting Guiana and Eastern Brazil, where it is called the Cigana or gipsy bird.

Birds of prey, Accipitres, have four families out of six in America. The Vulturidæ has been divided into two sub-families, one the Vulturinæ, true vultures, being confined to the Old World, and the other, the Sarcorhamphinæ, to the New World. This latter contains the great condor, *Sarcorhamphus condor*, which soars to very high elevations in the Andes.

The Grallæ, waders and running birds, have a large representation in America. Of the nineteen families fifteen have species there, and of these seven are confined to the New World.

Of the order Anseres, or swimming birds, each of its eight families is represented in America, and five are in both North and South America. The Antarctic Penguins appear on the coast of Peru and the Arctic Columbidæ, auks, guillemots, etc., in the northern part of the continent. The inland family, Anatidæ, ducks, geese and swans, range all over both North and South America.

The Struthiones, or wingless birds, have in America a very small representation, the Rhea, with three species, being the only genus of the order to be found in the New World.

Reptilia and Amphibia.

The reptilian and amphibian fauna of America is, like the avian, chiefly developed in the southern part of the continent.

The order Ophidia, or snakes, has fifteen out of twenty-five families in America chiefly confined to the tropical and forest regions, though the rattlesnakes may be found as far northwards as Canada on the east and British Columbia on the west. The great boa is confined to tropical America, but one species of the same family, Pythonidæ is in California. The family Viperidæ, which gives to this country our only venomous snake, is entirely absent from America.

Of the order Lacertilia, or lizards, there are fifteen out of twenty-seven families represented in America, and of the fifteen no less than eight are peculiar to that continent. The Iguanas have a few species in the Fiji and Galapagos islands, and are, it is said, in Australia, but with such exceptions these interesting reptiles, extending to 236 species, are American. On the other hand, chameleons are quite absent from both North and South America.

While both crocodiles and alligators are in America, the genus *Alligator* is restricted to that continent ranging southwards from the Lower Mississippi, but it is not in the West Indian islands. The third family of the order Crocodilia, Gavialidæ, is entirely absent from the western continent.

The order Chelonia has all its families represented. Tortoises are abundant in both North and South America, and the marine turtles are in the warm seas on the coasts of the tropical regions.

Of the Amphibia, six out of twenty-two families are peculiar to America, and all the others except two are to be found in one or other parts of the continent, so that there are twenty out of twenty-two families represented in the New World. Of the salamanders there are several genera, of the toads six genera, and of the frogs eight genera. *Rana*, the typical genus of frogs, is not in South America, but abundant in Central and North America. The well known frog of this country, *Rana temeraria*, and the edible frog of France, *R. esculenta*, are, however, not known in America. The remarkable animals called tree frogs have many species in America, three families of these amphibians being represented, two in the Nearctic and all three in the Neotropical region.

The American Fauna compared with that of the Old World.

Such is the great difference between the vertebrate faunas of the northern and southern parts of America that it is necessary to consider each separately, and to compare the one with the fauna of the northern and the other with that of the southern part of the Old World. Thus the faunas of the Nearctic and Palæarctic regions may be conveniently and usefully compared, and the fauna of the Neotropical region with the animals of the southern lands of the Old World, comprising the Ethiopian, Oriental and Australian regions, which I will call by the comprehensive term, Palæotropical.

For brevity as well as clearness these comparisons are best stated by a tabular arrangement. In these, as given below, the first column contains the names of the families represented in the American region and not in the corresponding one of the Old World, in the second and middle column is stated the families common to both the New World and the Old World regions; and in the third column are the names of the Old

World families that are not represented in the corresponding zoological region of America.

The Nearctic and Palæarctic Faunas compared.

Nearctic families not in Palæarctic Region.	Families common to both Regions.	Palæarctic families not in Nearctic Region.
	MAMMALIA.	
	Primates.	
		Cynopithecidæ.
	Cheiroptera.	
Phyllostomidæ.	Vespertilionidæ.	Pteropidæ.
	Noctilionidæ.	Rhinolophidæ.
	Insectivora.	
	Talpidæ.	Macroscelididæ.
	Soricidæ.	Erinaceidæ.
	Carnivora.	
Procyonidæ.	Felidæ.	Viverridæ.
	Canide.	Hyænidæ.
	Mustelidæ.	Æluridæ.
	Ursidæ.	
	Otariidæ.	
	Trichechidæ.	
	Phocidæ.	
	Ungulata.	
	Suidæ.	Equidæ.
	Cervidæ.	Camelidæ.
	Bovidæ.	
	Hyracoidæ.	
		Hyracidæ.
	Rodentia.	
Saccomyidæ.	Muridæ.	Spalacidæ.
Haploodontidæ.	Dipodidæ.	Myoxidæ.
Cercolabidæ.	Castoridæ.	Octodontidæ.
	Sciuridæ.	Hystricidæ.
	Lagomyidæ.	
	Leporidæ.	

Nearctic families not in Palæarctic Region.	Families common to both Regions.	Palæarctic families not in Nearctic Region.
	Marsupialia.	
Didelphyidæ.		
	BIRDS.	
	Passeres.	
Chamæidæ.	Turdidæ.	Timaliidæ.
Carebidæ.	Sylviidæ.	Panuridæ.
Mniotittidæ.	Cinclidæ.	Pymonotidæ.
Vireonidæ.	Troglodytidæ.	Oriolidæ.
Icteridæ.	Certhiidæ.	Muscicapidæ.
Tanagridæ.	Sittidæ.	Nectariniidæ.
Tyrannidæ.	Paridæ.	Dicæidæ.
	Laniidæ.	Sturnidæ
	Corvidæ.	Pittidæ.
	Ampelidæ.	
	Hirundinidæ.	
	Pringillidæ.	
	Alaudidæ.	
	Motacillidæ.	
	Picariæ.	
Trochilidæ.	Picidæ.	Yungidæ.
	Cuculidæ	Coraciidæ.
	Alcedinidæ.	Moropidæ.
	Caprimulgidæ.	Upupidæ.
	Cypselidæ.	
	Psittaci.	
Conuridæ.		
	Columbæ.	
	Columbidæ.	
	Gallinæ.	
Cracidæ.	Tetraonidæ.	Pteroclidæ.
	Phasianidæ.	Turnicidæ.
	Accipitres.	
	Vulturidæ.	
	Falconidæ.	
	Pandionidæ.	
	Strigidæ.	

Nearctic families not in Palæarctic Region.	Families common to both Regions.	Palæarctic families not in Nearctic Region.
	Grallæ.	
	Rallidæ.	Glaredidæ.
	Scolopacidæ.	Otididæ.
	Charadriidæ.	Phænicopteridæ.
	Gruidæ.	
	Ardeidæ.	
	Plataleidæ.	
	Ciconiidæ.	
	Anseres.	
	Anatidæ.	
	Laridæ.	
	Procellariidæ.	
	Pelecanidæ.	
	Colymbidæ.	
	Podicipidæ.	
	Alcidæ.	
	REPTILIA.	
	Ophidia.	
Pythonidæ.	Calamariidæ.	Typhloyidæ.
	Oligodontidæ.	Psammophidæ.
	Colubridæ.	Erycidæ.
	Homalopsidæ.	Viveridæ.
	Elapidæ.	
	Crotalidæ.	
	Lacertilia.	
Chirotidæ.	Zonuridæ.	Trogonophidæ.
Teidæ.	Scincidæ.	Amphisbænidæ.
Chalcidæ.	Geckotidæ.	Varanidæ.
Iguanidæ.		Lacertidæ.
		Gymnophthalmidæ.
		Ophiomoridæ.
		Sepidæ.
		Agamidæ.
		Chamæleonidæ.
	Crocodilia.	
Alligatoridæ.		

Nearctic families not in Palæarctic Region.	Families common to both Regions.	Palæarctic families not in Nearctic Region.
	Chelonia.	
	Testudinidæ.	
	Trionychidæ.	
	Cheloniidæ.	
	AMPHIBIA.	
	Urodela.	
Sirenidæ.	Proteidæ.	
Amphiumidæ.	Menopomidæ.	
	Salamandridæ.	
	Anoura.	
Engystonidæ.	Bufonidæ.	Bombinatoridæ.
	Alytidæ.	Discoglossidæ.
	Hylidæ.	
	Polypedatidæ.	
	Ranidæ.	

From this tabular statement it will be found that there are twenty families of mammalia, forty of birds, and twenty of reptilia and amphibia, or no less than eighty families of vertebrates common to the Nearctic and Palæarctic regions, and that while there are forty-eight Palæarctic families not represented in the Nearctic region, there are only twenty-three Nearctic families not in the Palæarctic region.

It also appears that seven families of the order Carnivora are common to both regions, while only one, Procyonidæ, is confined to the Nearctic. Of birds fourteen families of the order Passeres are represented in both regions, and five of Picariæ, while of Accipitres, birds of prey, all four families are in both regions. Of Grallæ seven families are common and not one peculiar to the Nearctic region. The order Anseres, or swimming birds, has, like Accipitres, all of its families, seven, represented in both regions.

These facts compel the conclusion that the northern parts of the Old and New Worlds have been connected by land and that the animals of North America have, for the most part at least, been derived from migrants from the Palæarctic region.

The Neotropical and Palæotropical Faunas compared.

Neotropical families not in Palæotropical Regions.	Families common to Neo and Palæotropical Regions.	Palæotropical families not in Neotropical Regions.
	MAMMALIA.	
	Primates.	
Cebidæ.		Simiidæ.
Hapalidæ.		Semnopithecidæ.
		Cynopithecidæ.
		Lemuridæ.
		Tarsiidæ.
		Chiromyidæ.
	Cheiroptera.	
Phyllostomidæ.	Vespertilionidæ.	Pteropidæ.
	Noctilionidæ.	Rhinolophidæ.
	Insectivora.	
	Centetidæ.	Macroscelididæ.
		Erinaceidæ.
		Potamogalidæ.
		Chrysochloridæ.
		Soricidæ.
		Galeopithecidæ.
		Tupaiidæ.
		Talpidæ.
	Carnivora.	
Procyonidæ.	Felidæ.	Cryptoproctidæ.
	Canidæ.	Viverridæ.
	Mustelidæ.	Protelidæ.
	Ursidæ.	Hyænidæ.
	Otariidæ.	Æluridæ.
	Phocidæ.	
	Sireniæ.	
	Manatidæ.	
	Ungulata.	
Camelidæ.	Tapiridæ.	Equidæ.
	Suidæ.	Rhinocerotidæ.
	Cervidæ.	Hippopotamidæ.
		Tragulidæ.
		Camelopordidæ.
		Bovidæ.

Neotropical families not in Palæotropical Regions.	Families common to Neo and Palæotropical Regions.	Palæotropical families not in Neotropical Regions.
	Proboscidia.	
		Elephantidæ.
	Hyracoidea.	
		Hyracidæ.
	Rodentia.	
Saccomyidæ.	Muridæ.	Spalacidæ.
Chinchillidæ.	Sciuridæ.	Dipodidæ.
Cercolabidæ.	Octodontidæ.	Myoxidæ.
Caviidæ.	Echimyidæ.	Hystricidæ.
	Leporidæ.	
	Edentata.	
Bradypodidæ.		Manididæ.
Dasypodidæ.		Orycteropodidæ.
Myrmecophagidæ.		
	Marsupialia.	
Didelphyidæ.		Dasyuridæ.
		Myrmecobiidæ.
		Peramelidæ.
		Macropodidæ.
		Phalangistidæ.
		Phascolomyidæ.
	Monotremata.	
		Ornithorhynchidæ.
		Echidnidæ.
	BIRDS.	
	Passeres.	
Certhiidæ.	Turdidæ.	Timaliidæ.
Cærebidæ.	Sylviidæ.	Panuridæ.
Mniotillidæ.	Cinclidæ.	Liotrichidæ.
Vireonidæ.	Troglodytidæ.	Phyllornithidæ.
Ampelidæ.	Certhiidæ.	Pycnonotidæ.
Icteridæ.	Sittidæ.	Oriolidæ.
Tanagridæ.	Paridæ.	Campephagidæ.
Oxyrhamphidæ.	Corvidæ.	Dicruridæ.

Neotropical families not in Palæotropical Regions.	Families common to Neo and Palæotropical Regions.	Palæotropical families not in Neotropical Regions.
Tyrannidæ.	Hirundinidæ.	Muscicapidæ.
Pipridæ.	Fringillidæ.	Pachycephalidæ.
Cotingidæ.	Motacillidæ.	Laniidæ.
Phylotomidæ.		Nectariniidæ.
Dendrocolaptidæ.		Dicæidæ.
Formicariidæ.		Ploceidæ.
Pteroptochidæ.		Sturnidæ.
		Artamidæ.
		Alandidæ.
		Eurylæmidæ.
		Pittidæ.
		Paictidæ.
	Picariæ.	
Rhamphastidæ.	Picidæ.	Yungidæ.
Bucconidæ.	Megalæmidæ.	Indicatoridæ.
Galbulidæ.	Cuculidæ.	Musophagidæ.
Todidæ.	Trogonidæ.	Coliidæ.
Monotidæ.	Alcedinidæ.	Leptosomidæ.
Steatornithidæ.	Caprimulgidæ.	Coraciidæ.
Trochilidæ.	Cypselidæ.	Meropidæ.
		Upupidæ.
		Irrisoridæ.
		Podargidæ.
	Psittaci.	
Conuridæ.	Psittacidæ.	Palæornithidæ.
		Cacaturidæ.
		Platycercidæ.
		Trichoglossidæ.
		Nestoridæ.
		Stringopidæ.
	Columbæ.	
	Columbidæ.	Dididæ.
		Didunculidæ.
	Gallinæ.	
Gracidæ.	Tetraonidæ.	Pteroclidæ.
Tinamidæ.	Phasianidæ.	Turnicidæ.
		Megapodiidæ.

Neotropical families not in Palæotropical Regions.	Families common to Neo and Palæotropical Regions.	Palæotropical families not in Neotropical Regions.
	Opisthocomi.	
Opisthocomidæ.		
	Accipitres.	
	Vulturidæ.	Serpentariidæ.
	Falconidæ.	
	Pandionidæ.	
	Strigidæ.	
	Grallæ.	
Chiconididæ.	Rallidæ.	Glareolidæ.
Thinocoridæ.	Scolopacidæ.	Otididæ.
Cariamidæ.	Parridæ.	Gruidæ.
Aramidæ.	Charadriidæ.	Rhinochetidæ.
Psophiidæ.	Ardeidæ.	
Eurypygidæ.	Plataleidæ.	
Palamedeidæ.	Ciconiidæ.	
	Phenicopteridæ.	
	Anseres.	
	Anatidæ.	
	Laridæ.	
	Procellariidæ.	
	Pelecanidæ.	
	Spheniscidæ.	
	Podicipidæ.	
	Struthiones.	
	Struthionidæ.	Casuariidæ.
		Apterygidæ.
		Dinornithidæ (Extinct).
		Palapterygidæ (Extinct).
		Æphyornithidæ (Extinct).
	REPTILIA.	
	Ophidia.	
Tortricidæ.	Typhlopidæ.	Xenobeltidæ.
Oligodontidæ.	Tortricidæ.	Uropeltidæ.

Neotropical families not in Palæotropical Regions.	Families common to Neo and Palæotropical Regions.	Palæotropical families not in Neotropical Regions.
Scytalidæ.	Calamariidæ.	Psammophidæ.
Crotalidæ.	Colubridæ.	Rachiodontidæ.
	Homalopsidæ.	Lycodontidæ.
	Dendrophidæ.	Erycidæ.
	Dryophidæ.	Acrochordidæ.
	Dipsadidæ.	Dendraspididæ.
	Scytalidæ.	Atractaspididæ.
	Amblycephalidæ.	Viperidæ.
	Pythonidæ.	
	Elapidæ.	
	Hydrophidæ.	
	Crotalidæ.	
	Lacertilia.	
Chirotidæ.	Amphisbænidæ.	Varanidæ.
Helodermidæ.	Lepidosternidæ.	Lacertidæ.
Teidæ.	Zonuridæ.	Chamæsauridæ.
Chalcidæ.	Gymnopthalmidæ.	Pygopodidæ.
Anadiadæ.	Scincidæ.	Aprasiadæ.
Chirocolidæ.	Geckotidæ.	Lialidæ.
Iphisadæ.		Sepidæ.
Circosauridæ.		Acontiadæ
Iguanidæ.		Agamidæ.
		Chamæleonidæ.
	Rhyncocephalina.	
		Rhyncocephalidæ.
	Crocodilia.	
Alligatoridæ.	Crocodilidæ.	Gavialidæ.
	Chelonia.	
	Testudinidæ.	Trionychidæ.
	Chelydidæ.	
	Cheloniidæ.	
	AMPHIBIA.	
	Pseudophidia.	
	Cæciliadæ.	

Neotropical families not in Palæotropical Regions	Families common to Neo and Palæotropical Regions.	Palæotropical families not in Neotropical Regions.
	Urodela.	
	Salamandridæ.	
	Anoura.	
Rhinophrynida.	Phryniscidæ.	Xenorhinidæ.
Hylaplesidæ.	Bufonidæ.	Dactylethridæ.
Plectromantidæ.	Engystomidæ.	
Pipidæ.	Bombinatoridæ.	
	Alytidæ.	
	Pelodryadæ.	
	Hylidæ.	
	Polypedatidæ.	
	Ranidæ.	
	Discoglossidæ.	

This comparison between the land animals of the southern lands of the western and eastern hemispheres, reveals some striking facts. Altogether there are ninety-seven families of land vertebrates common to the two hemispheres. Of these, nineteen are mammals, forty-one birds and thirty-six reptiles and amphibians.

Of Carnivora, eight families are common; of Rodentia, five; while of birds there are, common, eleven families of Passeres, seven of Picariæ, all four of Accipitres, eight of Grallæ, and all six of Anseres. Of reptilia, fourteen families of snakes are represented in both New and Old Worlds, six of lizards and three of Chelonians; while of amphibians there are ten families of the order Anoura (toads, frogs, etc.), common to the two hemispheres.

On the other hand there is no family of Primates, none of Proboscidia, none of Edentata and none of Marsupialia, common to the Old World and the New, and as has been before stated, there is no species of the order Monotremata in America.

Fossil Vertebrate Fauna of America, Quaternary and Tertiary.

Although the affinities of the living fauna of the New World with that of the Old World are obvious, they are not so strongly marked or conspicuous as were the relations of the

American mammalian fauna of Quaternary and Tertiary times with the mammals now inhabiting the eastern hemisphere.

Recent geological and palæontological work in America both north and south, has brought to light a wonderful mammalian fauna that has been of the utmost value for both biological and distributional purposes.

In North America, Leidy, Cope and Marsh have disinterred and described the remains of many genera of extinct as well as of living types from the Post Pliocene deposits of Nebraska forming the so-called "Bad Lands," and from the Tertiaries of Colorado and Wyoming about forty genera have been obtained.

In South America, the caves of Central Brazil have furnished from the deposits on their floors a vast number of small bones, estimated at seven millions, and from these over 100 species of mammalia have been determined. The Post Pliocene and Pliocene beds of the Pampas gave many years ago the remains of large mammals of the orders Edentata and Ungulata, including the great Megatherium and the giant armadillo, Glyptodon, that are so prominent in our Natural History Museum.

Patagonian Tertiary fossils received the attention of Florentino Ameghino, who named a great number of species, and within the last ten years systematic explorations of the beds exposed near the sea on the eastern coast of Patagonia extending as far south as Punta Arenas on the Straits of Magellan have been carried out by the Princeton University of the United States, and the fossil fauna revealed has been critically examined, described and determined by eminent palæontologists and a sumptuously printed report of this important investigation has been published at the cost of Mr. Pierpont Morgan. The chief fossiliferous deposits called the Santa Cruz Beds, were found by Professor Ortman to be of Miocene age, and their fossils have largely added to the species and the genera of the Tertiary fauna of America.

The most remarkable feature of the American mammalian fossils is the abundance of the remains of families now extinct or very sparsely represented in the New World, but which are now conspicuous in the Old World, as, for example, those represented by horses, oxen, sheep, elephants, rhinoceroses, camels, lions and tigers; and the general result of a close examination is to find more generalised types in the older and more specialised types in the newer deposits.

The following is a brief summary of the American Quaternary and Tertiary vertebrate fauna.

In Primates, twelve genera allied to the Lemuridæ were found in the Lower Eocene of Wyoming, an altogether Old World living family, while the Miocene of North America and the Quaternary of the Brazilian caves contain remains of true monkeys but still of the American type, that is, Platarrhine, so that no Catarrhine monkey appears in either the fossil or the living fauna of America. This is very noteworthy, and has led to the conclusion by some that the monkeys of America have had a separate western origin.

Both in the Brazilian cave deposits and in the Miocene of America, species of the order Cheiroptera have been found quite like recent European species, our common bats.

Of Insectivoræ in the Post Pliocene a single tooth has been found, but in the Upper Miocene of Dakota there are two genera, *Lepictis* and *Ictops*, while in the Miocene of Colorado, Cope discovered four genera and in the Eocene of Wyoming, two others.

The fossil Carnivora of America indicate a former greater abundance of carnivores there than at present. In the Quaternary deposits of Texas there are two species of Felis as large as lions, four species of Canis larger than wolves, two bears and some extinct genera; and in the Brazilian caves there have been found five species of Felis, the remarkable *Machairodus*, or sabre-toothed tiger, which inhabited our Devonshire caverns, besides species of the families Canidæ, Mustelidæ, Procyonidæ, and Ursidæ. From the Miocene of Dakota, too, the bones of *Machairodus* have been obtained, and from the Miocene of Colorado and Dakota four species of *Canis* and three species of *Hyænodon*, an extinct genus that is a noteworthy illustration of generalised forms since it was allied not only to hyænas, but also to wolves, cats, and weasels. In the older Eocene beds of Wyoming and New Mexico, twelve genera of the order Carnivora have been found, six or seven of them allied to *Hyænodon*.

The greater approximation of the past fauna of America to that of the Old World is, however, most conspicuously shown by the great order Ungulata. As is well known all the present horses of America are descended from progenitors introduced into that continent since the Spanish conquest of Peru, and that the family Equidæ is not represented by any living indigenous American species. Yet the fossil remains of horses in the Western Continent are abundant, demonstrating that they once flourished in America and became extinct there before the recent period. From the Post Pliocene of North

America six species of *Equus* have been described, and in the South American bone caves the genus is also well represented. But this is by no means all, for when mammalian fossils of the older Tertiary deposits are examined it is found that horse-like animals lived quite through Tertiary times to as far back as Lower Eocene. And it is a very important scientific fact that the differentiation of these fossils from the present equine type of Europe and Asia, *Equus caballus*, increases with the geological age of the deposits in which they occur. So markedly is this the case that, from American fossils, a chronological series of genera of Equidæ gradually approximating to *Equus caballus* can be constructed. The older the genus the smaller the animal and the more unlike is the foot to the single-toed hoof of the horse.

Series of American Equidæ.

Equus.	Single-toed hoof.	Quaternary.
Pliohippus.	Size of ass, single-toed.	Pliocene.
Protohippus.	Two small lateral toes but functionless.	„
Hipparion.	„	„
Auchippus.	„	„
Merychippus.	„	„
Myohippus.	„	„
Anchitherium.	Size of large goat, three toes.	Miocene.
Miohippus.	„	„
Mesohippus.	„	„
Orohippus.	Size of fox, four toes.	Eocene.
Eohippus.	Four toes and one undeveloped.	„
Phenacodus.	Five toes.	Lowest Eocene.

There are also forms such as the Parahippus, the Lophiodon, and the Palæosyops, which are more generalised and partake of the characters of both Hippidæ and Tapiridæ.

Again, the rhinoceros is not represented in the present American fauna, but in Pliocene and Miocene times the family Rhinoceratidæ was represented in America by the genera *Rhinoceros*, *Aceratherium*, *Hyracodon*, and *Diceratherium*. The remarkable extinct family Brontotheridæ, some of the members of which attained the size of elephants, with four toes to the front and three to the hind feet, has been given to science by the Miocene of Colorado.

The Arctodactylæ or even-toed ungulates were also abundant in America in Tertiary times, although there are now but few indigenous species. Remains of Suidæ, swine, represented at present only by the Peccaries, are numerous in Pliocene and Miocene deposits. *Hyopotamus* is from the Miocene of Dakota, Delawar, and Colorado, and *Elotherium* (placed by Marsh in a new order, Tillodontia), and three other genera are from the Miocene of Oregon and the Eocene of Wyoming and New Mexico. The remarkable family Camelidæ which has now only two genera in the Old World and one genus in the New World, had in the Tertiary period five genera in America of which one, *Pœbrotherium*, combined resemblances to the Old World camel and the New World llama. The Bovidæ which now has in America only the bison and the bighorn sheep as indigenous animals, had in Tertiary times seven genera, one, *Agriocharus*, going back to the Eocene. The two well-known genera, *Palæotherium* and *Anoplotherium*, that Cuvier made famous by his descriptions of the mammalian fossils of the Upper Eocene of the Paris Basin, are in the Eocene of the Pampas of Argentina in South America, and furnish another link connecting the American Tertiary fauna with that of Europe.*

The Proboscidea are now quite absent from America, but in the Post Pliocene and Pliocene of North America there are two species of elephants and two species of mastodons, and in the Newer Pliocene one species of each genus, while in South America there is a species of *Mastadon* in the Brazilian cave deposits and another in Andean beds.

The extensive order Rodentia was, as it is at present, well represented in America, and the remains of members of the family Muridæ give in Pliocene, Miocene and Eocene beds, several extinct as well as recent genera. Species of twenty genera representing six families of Rodentia have been described from the Santa Cruz beds of Patagonia by Professor Scott of Princetown University.

Fossil Edentata are very important. Those from the Quaternary deposits of the Brazilian caves and the Pleistocene and Pliocene beds of Argentina, Patagonia and Paraguay, are well known. These edentates are of great size, and include the gigantic *Megatherium*, *Mylodon*, *Scelidotherium*, *Megalonyx*, *Glossotherium*, and the great armadillo, *Glyptodon*. Mr.

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* Dr. Smith Woodward informs me that this is an error; and that the jaws thus originally named by Oscar Schmidt belong to the genus *Proterotheriidæ*.—ED.

Lydekker has recently examined and determined the remains of fifty-five species of edentates from the Pleistocene beds of Patagonia. In North America have been found *Megatherium*, *Megalonyx* and *Mylodon*, and from the Pliocene of California, Marsh has described the genus *Morotherium*.

From the Miocene Santa Cruz beds, Scott has determined species of twenty-nine genera of Edentata. These were very much smaller animals than the Pleistocene species before known, and approach the size of the South American living edentates.

Of Marsupialia which now gives the opossums to both South and North America, there are the remains of numerous species in the Brazilian caves, and the genus *Didelphys* has been found in the Post Pliocene deposits of South Carolina. The Miocene beds of Santa Cruz give a remarkable assemblage of Marsupial fossils, for Sinclair has described twenty species, while no less than eighty-seven had been previously named by Ameghino.

No remains of the lowest order of Mammalia, Monotremata, have been as yet discovered in America, and as there is no living American species, we have no evidence of a monotreme ever having existed in the New World.

Of remains of the class Aves, or birds, little need be said. The prolific cave deposits of Brazil have yielded many small avian bones from which thirty-four species of birds have been determined, including two species of *Rhea* and a species of the curious genus *Opisthocoma*, both genera being exclusively American. The turkey, *Meleagris*, has been found in both Post Pliocene and Miocene deposits.

The Quaternary and Tertiary Reptilia and Amphibia of America have not given many species, though tortoises are numerous in the Miocene and Eocene of North America, and several species of crocodile and a chameleon have been found in the Eocene. This is important, since there are no chameleons now in America. A large salamander, allied to the living *Menopomo* of North America, has also been discovered.

Former Land Connections, Atlantis, etc.

That America has been connected by land with the Old World will be evident, I think, from the facts that have now been stated, and that the animals at present living there have had their origin either directly or by descent mainly from species which have inhabited the eastern hemisphere, can scarcely be doubted. But there remains the question, what and where was that former connecting land? Was it the

Atlantis of Plato in Mid Atlantic, was it an Antarctic land or archipelago extending between the southern extremities of Africa and South America, and connecting these with New Zealand and Australia, was it a northern land uniting Labrador and Greenland to Europe, and Alaska and British Columbia to Asia, or were there more than one or even two terrestrial bridges for the passage to the New World of the ancestors of its present animals?

This question has been so much discussed that a large number of authors of eminence can be quoted who have written both tentatively and very decidedly on the subject.

The affinities of the fauna of the northern parts of America and that of the northern parts of the Old World, or of the Nearctic and Palæarctic regions, are so many and so strong, and the fossil fauna of the two regions is so confirmatory, that a former land connection between them is a conclusion that at once suggests itself. And when the present relative position of these two great land areas that are separated by but narrow seas, and the comparative shallowness of these seas, are considered, there is no difficulty in admitting this conclusion.

Such land connections would be produced by elevations by no means greater than those we know to have taken place in Europe and Asia since Eocene, or indeed, since Miocene times. There is continuous sea-bottom of less than 2,000 fathoms depth between Labrador, Greenland, Iceland and Scotland, and the greatest depth between Siberia, Kamtchatka and Alaska, is also less than 2,000 fathoms, so that an elevation of the floor of the northern seas above its present level of 12,000 feet, would give these two great zoological bridges.

Great elevations have taken place since Eocene times in Central Europe where the Alps show Tertiary rocks at 11,000 feet above sea-level, and of much more than 12,000 feet in Asia where the Himalayas show Pliocene deposits at 14,000 feet above the level of the sea; and a change of level of 12,000 feet in later geological times in one or more areas makes it difficult to refuse to admit possible similar changes of level in other areas.

Nor would there be any climatal difficulty in animal migration by these northern lands. From the general mildness of the climate of the northern regions in pre-Glacial times, there would be no impediment to the spread of a temperate fauna that present boreal conditions would interpose.

Thus we may regard it as established that the northern part of North America was joined on the east to Europe, and on the

west to Asia, giving two great land bridges by which the terrestrial animals of the Old World could travel away from their centres of origin, some northwards and westwards and some northwards and eastwards, until what is now North America was reached, colonised and populated.

We cannot therefore, I think, hesitate to conclude that, after allowing for migrations from the south, much of the fauna of the Nearctic region is descended from animals, some of which came from Europe by a north-west land extending to Iceland and Greenland and on to Labrador, and some of which came from Asia by a north-east land extending from Siberia by Kamtchatka and the Aleutian Islands to Alaska and Western Canada.

So far I do not think there is anything here stated that will be taken exception to by zoogeographers. But now we approach a very debatable portion of our subject. This is the question of the origin of many animals in North America and the West Indies having affinities with species of the Mediterranean and North African areas of the Old World, and of the South American fauna which is so different from the fauna of North America, while it has such strong affinities with the fauna of the southern extremities of the land areas of the eastern hemisphere.

On this question eminent authorities differ very widely, and the evidence and arguments in support of the different views are so important and abundant that it will be impossible to give here even the briefest statement of them, but a summary may perhaps be attempted.

The relations existing between South American fossil mammals and mammals of the Australian region are very pronounced. The discovery of a large number of fossil marsupials both in Brazil and Patagonia is of great importance, and when it is borne in mind that marsupials are not to be found out of America except in the Australian region and that only two species, both of the genus *Didelphys*, are in North America, and that, moreover, while the fossil marsupials of Europe and the British Islands are of Mesozoic and Eocene ages the Patagonian fossils are Miocene, it will be seen that there is strong evidence of land connection with the Australian region in Tertiary times.

But in addition to the mammalia, the Patagonian Tertiary invertebrate fauna gives 151 species which, with the exception of two or three, have not been obtained in North America nor indeed in the northern hemisphere, while fifteen are in New

Zealand and eleven others are closely allied to New Zealand species, so that Dr. Ortman remarks that the only clearly marked relations of this fauna are with Chili, New Zealand and Australia, but speaking of the entire fossil fauna of the Patagonian Miocene he writes: "Thus we see that, in the Miocene Patagonian beds, we must distinguish two chief faunal elements: a tropic-sub-tropical one, which shows relations to the tropical parts of the rest of the earth (and through these with the sub-tropical faunas of the northern hemisphere in Europe and North America), and an antarctic element which is peculiar to the southern hemisphere, and which shows relations only to the faunas belonging to or connected with ancient Antarctica."*

The "tropic-sub-tropical" element of which Ortman speaks and which is conspicuous, points undoubtedly to a former land connection with Africa to which Madagascar was united in Tertiary times.

Such a land connection of the southern terminations of the continents was suggested to Hooker as long ago as 1847 by the affinities of the floras of these sub-antarctic lands. A relationship between the Mollusca of Brazil and Africa was shown to exist by Von Ihering. The edentates, sloths and armadillos, now living, and the gigantic extinct forms, *Megatherium*, *Mylodon*, *Glyptodon*, etc., of South America, are unlike anything in the Palæarctic region either living or fossil, and are allied only to two families in Africa and one in the Oriental region. Africa, too, is the habitat of the ostrich, and the only other struthious birds are in South America and Australasia.

The extraordinary number of families of reptiles and amphibians, particularly of snakes, common to the southern lands of the two hemispheres, is very cogent evidence for a former connection with Africa. This reptilian and amphibian fauna is mainly a tropical one and cannot be looked upon, therefore, as having come by way of the northern parts of the continents. It is also plainly indicated by the fossil shells and corals of the West Indies of Miocene age that there was a sea barrier between the northern and the southern parts of America in Tertiary times. Thus it seems not unreasonable to conclude that while there was a separating sea between South and North America in the Tertiary period, a land connection existed in the south between Patagonia and the Australian and Ethiopian regions.

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* *Princeton University Report* vol. iv, p. 324.

Notwithstanding, however, the marked affinity between the present and past animals of South America and those of the Australian region, and between a portion of both the fauna and the flora of South America and the animals and plants of Africa and Madagascar, Dr. Russell Wallace has opposed with his powerful pen the former direct connection between America and either Australia or Africa. In his view, all the animals of the southern part of America are derived from the north, and the animals of Australia and South Africa are derived from northern migrants likewise, and so the present faunas of the southern extremities of both hemispheres have been derived from more northern centres of dispersal; that, in fact, earlier types migrated or were driven to the south of both the Old and New Worlds, and there continued while newer and higher types were developed in the older areas of origin. Thus he regards the marsupials, the edentates, and the struthious Rhea of South America as survivals equally with the marsupials of Australia, the few edentates of Africa and India, and the ostriches and emus of Africa and Australasia.

Wallace therefore only admits land connections between America and the Old World in the northern hemisphere, and following Huxley maintains the permanence of the great oceanic depressions of the globe. Since these views were published, however, the additional evidence from the Patagonian Tertiaries seems to compel an admission of former land connection with the Old World in the southern hemisphere.

The hypothesis of a mid-Atlantic continent uniting Europe and Africa with the West Indies and America has a fascination for many, and has been strongly advocated by authors who must command attention. The Atlantis of Plato's *Timæus* was a large island beyond the Pillars of Hercules, but the Atlantis of modern authors is greater, since it is a continent extending quite across the Atlantic Ocean even where it is widest and deepest. This would, it is contended, afford a direct passage for the terrestrial and coastal fauna and flora of the tropical and sub-tropical parts of the Old World to the West Indies and the American continent, and so explain the relations existing between the faunas and floras of the Mediterranean and West African areas, the Atlantic islands, and the tropical and sub-tropical parts of the New World.

This view has recently been advocated by such an eminent zoogeographer as Dr. Scharff, who cites in its support the distributional facts furnished by the Azores, the Canary

Islands, the Cape Verde Islands, Madeira, St. Helena, and Fernando de Noronha, all of which have seas of more than 1,000 fathoms depth separating them from continental land, and so have been considered oceanic islands.

The permanence of Ocean Basins, which the Atlantis hypothesis opposes, is an important subject, and has engaged the attention of very eminent men. Amongst those in favour of that permanence may be mentioned Huxley, Wallace, Sir Archibald Geikie, Asa Gray, and Professor Oliver, who based their conclusions on the higher specific gravity of the earth's crust below the oceans, the general absence of sedimentary rocks in oceanic islands, the absence of deep sea deposits in continents, and the agreement of plant and animal life and the present arrangement of land areas. In his Presidential Address to the Geological Society in 1890, Dr. Blanford examined these grounds in detail, and then expressed the opinion, "that whilst the general permanence of ocean basins and continental areas cannot be said to be established on anything like firm proof, the general evidence in favour of this view is very strong."

Amongst those who have favoured the opposite conclusion are Lyell, Darwin, Edward Forbes, Andrew Murray, Heer, Unger, Leidy, Hutton, Guppy, Newmayer, Von Ihering, Suess, Laparent, and Dr. Scharff. Although I have the utmost respect for the opinions of these authors, I must confess that I fail to find anything in geology or zoological distribution requiring such a complete change of the geography of the world as would be effected by continental land occupying areas where now are the deepest parts of the oceans. While recognizing the cogency of the before-mentioned arguments for the permanence of ocean basins, I will venture to add one more which I hope may contribute to give the "firm proof" that Dr. Blanford desired.

The former elevation of the floors of the abysmal depths of the oceans above the surface of the sea has been accepted, I think, in a large measure from the assumption of the globe having but a thin solid crust, which is vertically mobile and flexible. Thus by its flexibility wrinklings on a stupendous scale would follow an accommodation of the exterior to the shrinkage of a cooling interior, and so oceanic depressions and continental elevations would be found in different areas at different times. Such an amount of flexibility, indeed, has been assumed, that Croll ascribed the great northern depression following the Glacial Period to the weight of the glacial ice.

It is many years since I came to quite other conclusions. In 1894 and 1896 at the Oxford and Liverpool meetings of the British Association, and to the Geological Society in 1895, I showed, I think, conclusively that there had been no appreciable shrinkage of the whole globe, or, in other words, no mean radial variation since Cambrian times. The elevations and depressions that have since taken place I regard as due to expansion and contraction of the underlying solid masses mainly by increase and decrease of temperature, and that these regional secular movements did not affect the general rigidity of the planet, which might be practically solid throughout. The oceanic depressed areas and the continental elevated areas are, it seems to me, original features produced by the consolidation of the globe, the *consistantior status* of Lord Kelvin, when there was a very decided shrinkage, and are so far permanent that subsequent surface movements have never been sufficiently great to obliterate them, but only to modify their outlines.

The conversion of the central Atlantic into a land area would require an elevation of the sea bottom of over 27,000 feet, and seeing that as the temperature of the lower depths of oceanic waters is uniformly about 32° F., or the freezing point of fresh water, there is, in this vast body of cold water, a permanent cause of non-expansion of the underlying masses, and, consequently, it seems to me, that the ocean basins have never been obliterated by the elevation of their floors into land areas, and that, therefore, the Atlantis hypothesis is untenable.

On the other hand I cannot accept Wallace's conclusion that the only land connection from the Old World to America was at the north, for an amount of elevation such as can be readily admitted would give land bridges in the southern seas connecting the extremities of the southern continents that would allow of, I think, not only the migration of the fauna of those extremities, but also of animals whose usual habitats were of a more tropical character.

To account for the relations existing between the faunas and floras of the southern lands of both hemispheres, H. O. Forbes, in 1893, supposed an Antarctica that connected Australia, New Zealand, the Fiji and Mascarine islands with South Africa and South America, and in 1895, Hedley, before the Royal Society of New South Wales, suggested a somewhat narrow strip of land, perhaps, sometimes, broken into islands, with a mild climate, extending across the South Pole from Tasmania to Tierra del Fuego. Other authors have advocated modifications

of these views, and Ortman, the most recent, takes a view intermediate between those of Forbes and Hedley.

Oceanic depths have been found to be from 2,000 to 4,500 fathoms under vast areas, surrounded by lesser depths, under extensive areas also, extending to the shore lines of the continents. Elevations, therefore, of 12,000 feet would give a great extension of present land areas while leaving the ocean basins with depths of water ranging to 15,000 feet even if a general and equal uprise of the whole ocean floor had taken place, which is by no means probable.

Such an amount of elevation would, I think, suffice for zoogeographical requirements, since it would give land connections in the north that would furnish bridges for the temperate animals of European and Asiatic lands, and in the south it would give connections either complete or nearly so between Australian, African and American lands, that would serve for the migration of both the sub-tropical and the tropical animals of the eastern hemisphere.

Such an elevation would also be sufficient for the geographical and geological changes of Tertiary and Quaternary times, for it would give the uprise that laid bare the now submerged continental shelf, united continental and some called oceanic islands, to the mainland, and gave those extensions seawards of existing river-valleys that Professor Hull and Professor Spencer have, on several occasions, brought before the notice of this Institute. It would also, I may add, be amply sufficient to raise the lower northern mountains above the snow-line and so produce the geographical and climatal conditions of the Glacial Period, while in the Pacific area it would suffice to give Darwin's land on the submerged summits of which are now a thousand coral islands, and yet there would be no obliteration of the Atlantic, the Pacific or the Indian oceans.

I venture, therefore, to conclude that an elevation of 12,000 feet at one time or another in different areas during the Tertiary and Quaternary Periods, which we have seen, may be readily conceded, while not affecting the permanence of ocean basins, would yet be sufficient to allow of all the animal migrations necessary for the faunal development that living animals or fossils in America reveal.

Discussion.

Mr. David Howard, F.C.S.—This interesting paper suggests many questions some of which it is perhaps impossible to answer. It is curious to find types of animals which formerly existed in both the New and the Old World and have died out in the New. Can we be sure that the types now found have continuously existed in the New World, or may not some at any rate have become extinct and been reintroduced from the Old World.

The question of ancient continents uniting, Europe and America, or India and Africa is fascinating to dream of, but difficult to prove. Such an idea requires of course relative alterations of elevation; and it must be remembered that any great upheaval from the bottom of the sea unless counterbalanced by a corresponding depression elsewhere would greatly alter this sea level.

Mr. Rouse.—In his able and exhaustive paper Professor Lobley has identified no American species of terrestrial mammal with any species native to the Old World; but one may say that the caribou is not determined to be specifically distinct from the reindeer of Lapland, that the polar bear is found along the northern coasts of Asia as well as of America, and that in the preserve of bisons made at Winnipeg some years ago, those beasts were found, if memory serves me correctly, to yield fertile offspring with the domestic cow. If the last fact be true, the progenitors of the bison may have easily been brought over in the first immigration by the Indians who first passed from Kamschatka into Alaska across the ice; and as for the polar bear and the reindeer they both undoubtedly crossed over polar icefields from the Old to the New World; the bear, as it is, often drifting for hundreds of miles upon icebergs and having been found swimming eighty miles from any land and with no ice in sight (*Living Animals of the World*, p. 124). These, however, are all the species that America shares with the other continents; whereas, if we accept the Darwinian theory and suppose Atlantis to have sunk out of sight a few hundred years before Plato wrote of it, we should nevertheless expect very many of the species that had

crossed by way of Atlantis between Africa and America to have maintained their identity until now. Professor Lobley rightly argues against the theory of a former Atlantis on the ground of the enormous depth of the ocean between western Africa and America: and to this I would add that in the late Dr. Daniel Wilson's lecture quoted by me after Professor Hull's paper on the "Fauna of Islands," a parallel was drawn between Plato's statement and the idea that the early discoverers had of America; one Elizabethan writer even speaking of it as an island, and the first French Colonists thinking that the River St. Lawrence was a channel leading to China and so calling its first rapids Chute de la Chine—a name that they have borne ever since. Doubtless, said Doctor Wilson, the Carthaginian mariners who left their coins upon the Azores, did at one time penetrate to America, and on their return described it, but were not able to reach it any more; so that the story went abroad that a rich and beautiful country beyond the Pillars of Hercules had dropped out of sight into the depths of ocean.

Professor H. LANGHORNE ORCHARD (in the Chair).—Professor Logan Lobley never addresses us without giving us something valuable, something for thoughtful consideration. It is a great advantage, in matters geological, to have the subjects introduced by so careful, so patient, so sound, an investigator.

The interesting comparison of the fauna of the western hemisphere with the fauna of the eastern, shows that while some forms are common to both hemispheres, others are restricted to the one hemisphere or to the other. This leads to the conclusion that migration is not the only factor concerned in faunal arrangement, and that animal life has had origin in more than one locality.

On the much debated question of the Permanence of Ocean Basins, the reasoning in the paper has much force. We shall probably conclude with the learned author that "an elevation of 12,000 feet," (or thereabout), "at one time or another in different areas during the Tertiary and Quaternary Periods, . . . would be sufficient to allow of all the animal migrations necessary. . ."

Whether or not the mystery of Atlantis is to be solved, as has been suggested, by the prior discovery of America, is a matter in regard to which we do well to be patient.

The series of "horse-like animals" invites some comments. If the more recent forms were the progeny of the less recent, then, as

regards toe development or structure, the series would present differentiation *backwards*, which is incompatible with Evolution. The genus Equus is found in the Upper Siwalik beds, from which circumstance it appears that Equus existed in the Upper Miocene, in which case Equus existed before forms supposed by Evolutionists to be its ancestors. In the three "horse-like forms"—Mesohippus, Miohippus, Protohippus, each genus is less modified in some respect than its predecessor. This has been pointed out by Scott;* from which it results that the earlier forms resemble Equus more than they resemble their immediate successors in the chronological series, another fact incompatible with Evolution. It is worth remarking also that later horse-like forms are not invariably larger than those preceding them; for Epihippus† in the Upper Eocene, is much smaller than Protorohippus† found in the Middle Eocene. And, with regard to Phenacodus, if account be taken of the long period from Phenacodus to Equus, the time necessary to derive this form from a non-ungulate form is so enormous as to be altogether inadmissible.

Mr. W. Woods Smyth.—I am thankful to Professor Logan Lobley for his paper—for its immense and widely gathered information and for its interesting subject matter. I regret to have to show good reason for refusing to accept his closing views upon the earth—upon land and ocean areas. In these Professor Lobley follows Lord Kelvin's idea that the earth originally became consolidated from centre to surface—Kelvin's *constantior status*. At the Cambridge Meeting of the British Association, 1904, the venerable geologist the Rev. Osmond Fisher, submitted satisfactory calculations to show that the folding convolutions and contortions of the earth rendered Lord Kelvin's theory of a primeval solid earth an impossibility.

The Author briefly replied.

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* *Transactions of the American Philosophical Society* (N.S.), 18, 1896, pp. 119, 120.

† These forms are in the American Museum Series.