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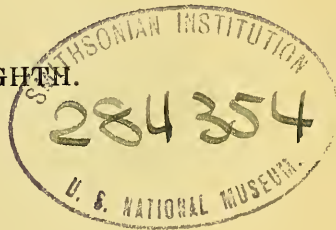
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THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

Quod si cui mortalium cordi et curæ sit non tantum inventis hæerere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant. —*Novum Organum, Præfatio.*

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singular group of Cervidæ, consisting of, at the very least, the following species:—

Cervus elaphus.		Cervus carnutorum.
— megaceros.		— Sedgwickii.
— capreolus.		— verticornis.
— Polignacus.		

The first three of these are not of Pliocene age, if the Mammaliferous strata of Auvergne, Marseilles, and the Val d'Arno be taken as the Pliocene standards. Their presence, therefore, in the Forest-bed points forwards rather than backwards in time, since they are abundant in the caves and river-deposits of the Pleistocene age. The next, on the other hand, is a well-known Pliocene species; while the *Cervus carnutorum* is common to the Forest-bed and the river-strata of St.-Prest, and the last two peculiar to the Forest-bed.

This peculiar mixture of Cervine species seems here to indicate that, in classification, the Forest-bed belongs rather to an early stage of the Pleistocene than to the Pliocene; and this inference is corroborated by the presence of the Mammoth, which is so characteristic of the Pleistocene age.

3. *The CLASSIFICATION of the PLEISTOCENE STRATA of BRITAIN and the CONTINENT by means of the MAMMALIA.* By W. BOYD DAWKINS, Esq., M.A., F.R.S., F.G.S.

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1. THE PRINCIPLE OF CLASSIFICATION.

THE Pleistocene period was one of very long duration, and embraced changes of great magnitude in the geography of Europe. The climate, which in the preceding Pliocene age, in Northern and Middle Europe, had been temperate, at the beginning of the Pleistocene gradually passed into the extreme arctic severity of the glacial period; and this change caused a corresponding change of the forms of animal life, the Pliocene species (whose constitutions were adjusted to temperate or hot climates) yielding place to those which were better adapted to the new conditions; and since, as we

shall presently see, there is reason for the belief that it was not continuous in one direction, but that there were pauses, or even reversions towards the old temperate state, it follows that the two groups of animals would at times overlap, and their remains be intermingled with each other. The frontiers also of each of the geographical provinces must necessarily have varied with the season; and the competition for the same feeding-grounds, between the invading and the retreating forms, must have been long, fluctuating, and severe. The passage, therefore, from the Pliocene to the Pleistocene fauna must have been extremely gradual in each area; and the lines of definition between the two must be, to a great extent, arbitrary, instead of being sufficiently strongly marked to constitute a barrier between the Tertiary and Posttertiary groups of life of Lyell, or between the Tertiary and Quaternary of the French geologists. The principle of classification which I shall adopt is that offered by the gradual lowering of the temperature, which has left its marks in the advent of animals before unknown in Europe; and I shall divide the Pleistocene deposits into three groups:—

1st. That in which the Pleistocene immigrants had begun to disturb the Pliocene mammalia, but had not yet supplanted the more southern animals. No arctic mammalia had as yet arrived. To this belongs the Forest-bed of Norfolk and Suffolk, and the deposit at St.-Prest, near Chartres.

2nd. That in which the characteristic Pliocene Cervidæ had disappeared. The even-toed Ruminants are principally represented by the Stag, the Irish Elk, the Roe, Bison, and Urus. *Elephas meridionalis* and *Rhinoceros etruscus* had retreated to the south. To this group belong the Brick-earths of the lower valley of the Thames, the river-deposit at Clacton, the Cave of Baume, in the Jura, and a river-deposit in Auvergne.

3rd. The third division is that in which the true arctic mammalia were among the chief inhabitants of the region; and to it belong most of the ossiferous caves and river-deposits in Middle and Northern Europe.

These three do not correspond with the Preglacial, Glacial, and Postglacial divisions of the Pleistocene strata in Central and North Britain, since there is reason to believe that all the animals which occupied Britain after the maximum cold had passed away, had arrived here in their southern advance before that maximum cold had been reached, or, in other words, were both Pre- and Post-glacial.

I shall first of all examine how this classification applies to Great Britain.

## 2. THE LATE PLEISTOCENE MAMMALIA FROM BRITISH RIVER-DEPOSITS.

The third or late division of the Pleistocene strata will be taken first. The evidence that it is far older than any of the Prehistoric\*

\* For definition of the term Prehistoric, see Introd. Brit. Pleistocene Mammalia, Paleont. Soc. 1866; "Prehistoric Mammalia of Great Britain," Cong. of Prehistoric Archaeology, Norwich, 1868, p. 269.

strata is clear and decisive. In many cases, as at Walton, in Essex, and Fisherton, near Salisbury, the former underlie the latter, and must therefore be older.

In other cases they form part of the basin in which the Pre-historic deposits lie, as in the case of the gravel-beds of Windsor or of London, and must therefore, from their position, be of higher antiquity than the latter. Nearly every valley in Great Britain (the glacier-areas, to which I shall return presently, being excepted) contains beds of brick-earth or of gravel, which were formed, as Mr. Prestwich\* has clearly shown, before the valleys were cut by the streams to their present depths; and the difference between the levels of these old river-terraces has been shown by that eminent observer to be a rough measure of their relative antiquity, the highest being the oldest. The Prehistoric deposits, on the other hand, occupy for the most part the bottom of the valleys, and are seldom raised much above the level of the present stream. There is also a marked difference between the two in the materials of which they are composed. The Prehistoric as well as the present alluvia are for the most part formed of clays, more or less stiff; and the gravels are composed of pebbles more or less evenly sorted; and both were formed under conditions of climate not very different from the present. The Pleistocene brick-earths, on the other hand, very seldom consist of stiff clays; and the gravels contain large and small pebbles and angular blocks confusedly mixed together, which indicate that the conditions under which they were formed were different from those which are now presented by the temperate region of Europe. But the difference offered by the fauna which they present is, perhaps, the most striking.

It will be unnecessary to give the river-deposits in Great Britain which have furnished the remains of the following animals, since they have already been published in the Quarterly Journal of the Geological Society, vol. xxv. pp. 192 *et seqq.*

It would, of course, be unreasonable to expect that the remains of all the animals inhabiting the country at the time would be present in one small river-deposit, and still more improbable that they would all be discovered in the small area which happens to be open for examination. By correlating, however, the animals from many localities, a fair estimate can be obtained of the whole fauna. The greater liability of one animal to drowning than another must be taken into consideration. For this reason the Otter, probably from its aquatic habits, is extremely rare, while the Squirrel, living in trees, would run little risk of a watery grave, and has only been found in one Pleistocene deposit in Great Britain. Altogether the following twenty-eight species of animals have left their remains to prove that they existed on the surface of the Pleistocene continent that was drained by the rivers in the deposits of which their remains have been found.

\* Philosophical Transactions, vol. cliv.



Homo, <i>L.</i> Man.	Bos primigenius, <i>Boj.</i> Urus.
Ursus arctos, <i>L.</i> Brown Bear.	Bison priscus, <i>Owen.</i> Bison.
— ferox, <i>Lewis &amp; Clark.</i> Grizzly Bear.	Hippopotamus major, <i>Desm.</i> Large Hippopotamus.
Mustela erminea, <i>L.</i> Ermine.	Sus scrofa (ferus), <i>L.</i> Wild Boar.
Lutra vulgaris, <i>L.</i> Otter.	Equus caballus, <i>L.</i> Horse.
Canis vulpes, <i>L.</i> Fox.	Rhinoceros hemitæchus, <i>Falc.</i> Slender Rhinoceros.
— lupus, <i>L.</i> Wolf.	— tichorhinus, <i>Cuv.</i> Woolly Rhinoceros.
Hyæna crocuta, <i>Zim.</i> , var. spelæa, <i>Goldf.</i> Cave-hyæna.	Elephas antiquus, <i>Falc.</i> Narrow-toothed Elephant.
Felis leo (spelæa), <i>L.</i> Cave-lion.	— primigenius, <i>Blum.</i> Mammoth.
Cervus megaloceros, <i>Hart.</i> Irish Elk.	Lemmus (?greenlandicus). Lemming.
— Browni, <i>Dawk.</i> Extinct Fallow-deer.	Spermophilus (? superciliosus). Pouched Marmot.
— tarandus, <i>L.</i> Reindeer.	Lepus timidus, <i>L.</i> Hare.
— capreolus, <i>L.</i> Roe-deer.	Mus musculus, <i>L.</i> Mouse.
— elaphus, <i>L.</i> Stag.	
Ovibos moschatus, <i>Blainv.</i> Musk-sheep.	

The mammalia of Acton Green, obtained by Col. Lane Fox, and named by Prof. Busk, F.R.S., all probably belong to the late Pleistocene division; for although the peculiar flat-antlered deer, *C. Browni*, and the Hippopotamus are found side by side, they are associated with the Mammoth and the Reindeer.

### 3. THE LATE PLEISTOCENE OSSIFEROUS CAVES OF BRITAIN.

It remains now to compare this fauna with that of the Ossiferous caves. In comparing the Table of the distribution of the Mammalia in Britain, which I have published in the Q. J. G. S. (vol. xxv.) with the above list, it will be seen that all the mammalia which are found in the latter, with the exception of *Ovibos moschatus*, occur also in the former. Those animals which are peculiar to the caves consist chiefly of the carnivores, the Cave-bear, Glutton, Leopard, Lynx, and Wild Cat, which would naturally haunt such places. The larger number of rodents obtained from the caves is due to the admirable way in which Mr. Ayshford Sanford has worked out the Mendip fauna, and is not the result of their absence from the river-beds; the same amount of care bestowed on the latter would probably equalize the numbers. It is therefore evident that the cave-fauna is identical with that of the river-strata, and that, consequently, both must be referred to the same point of geological time—to a time when this group of animals lived in the caves and valleys of the Pleistocene continent. This was the conclusion to which Dr. Falconer was led by the examination of the caves of Gower, and it has been amply proved by every subsequent discovery.

The late Pleistocene corresponds in part with the Reindeer-period of M. Lartet; but it comprehends also his three other periods; for the Spotted Hyæna, the Lion, the Cave-bear, the Mammoth, the Woolly Rhinoceros, the Bison, and the Urus are so associated together with the Reindeer in the caves and river-deposits of Great Britain, that they do not afford a means of classification. The arctic division of the Mammalia was then in full possession of the area

north of the Alps and Pyrenees. It also corresponds with the Post-glacial period, as I have used the term, and covers the vast lapse of time, extending from the beginning of the era of intense cold down to the enormous break which separates the Pleistocene from the Prehistoric division of the Tertiary period.

#### 4. MAGNITUDE OF THE INTERVAL BETWEEN THE LATE PLEISTOCENE AND THE PREHISTORIC AGES IN BRITAIN.

The magnitude of the break in time between the Late Pleistocene and Prehistoric ages may be gathered not merely from the physical evidence, but also from the disappearance from Britain, in the interval, of the following species, of which the last five, and possibly the last seven, have become extinct.

Glutton.	Bison.	Cave-Bear.
Spotted Hyæna.	Hippopotamus.	Rhinoceros hemitæchus.
Panther.	Lemming.	—— tichorhinus.
Lion.	Hamster.	Elephas antiquus.
Lynx.	Tailless Hare.	—— primigenius.
Musk-sheep.	Lepus diluvianus.	
Urus.	Arvicola Gulielmi.	

All these animals were eliminated out of the fauna before the Prehistoric deposits were accumulated; and the remainder lived on through the Prehistoric down into the Historic period.

#### 5. THE MIDDLE DIVISION OF THE PLEISTOCENE MAMMALIA.

The middle division of the Pleistocene mammalia must now be examined, or that from which the characteristic Pliocene Cervidæ had vanished and were replaced by the invading forms from the temperate zones of Northern Asia. It is represented in Britain by the mammalia obtained from the Lower Brick-earths of the Thames-valley, at Crayford, Erith, Ilford, and Gray's Thurrock, by those from the deposit at Clacton, and most probably by those from the older deposit in Kent's Hole, and by the *Rhinoceros megarhinus* of Oreston. They consist of

Homo.	Cervus Browni.
Felis leo (spelæa), <i>Goldf.</i>	—— capreolus, <i>Linn.</i>
—— catus, <i>Linn.</i>	Ovibos moschatus.
Hyæna crocuta, var. spelæa.	Elephas antiquus, <i>Falc.</i>
Ursus ferox, <i>Lew. &amp; Clark.</i>	—— primigenius, <i>Blum.</i>
—— arctos, <i>Linn.</i>	Equus caballus, <i>Owen.</i>
Canis lupus, <i>Linn.</i>	Rhinoceros tichorhinus, <i>Cuv.</i>
—— vulpes, <i>Linn.</i>	—— hemitæchus, <i>Falc.</i>
Lutra vulgaris, <i>Erxl.</i>	—— megarhinus, <i>Christ.</i>
Bos primigenius, <i>Boj.</i>	Sus scrofa, <i>Linn.</i>
Bison priscus, <i>Owen.</i>	Hippopotamus major, <i>Desm.</i>
Cervus megaceros, <i>Hart.</i>	Castor fiber, <i>Linn.</i>
—— elaphus, <i>Linn.</i>	Arvicola amphibia, <i>Desm.</i>

The discovery, by the Rev. O. Fisher, of a flint-flake in the undisturbed Lower Brick-earths of Crayford, in the presence of the writer, in April 1872, proves that man was living at the time of the accumulation of these fluviatile strata.

If the mammalia from these deposits be compared with the Pre-

glacial or Pliocene on the one hand, and with the Late Pleistocene on the other, it will be seen that they are linked to the former by the *Rhinoceros megarhinus*, and to the latter by the *Ovibos moschatus*. The absence of the Reindeer, which was so numerous in the valley of the lower Thames, and the abundant remains of the Stag, seem to me to point backwards rather than forwards in time, and to imply that the Lower Brick-earths are not of Late Pleistocene age, just as the absence of the characteristic Early Pleistocene species shows that they are not of that age. The evidence seems to me sufficient to establish a stage intermediate between the two. Nevertheless the evidence is sufficiently conflicting to cause Dr. Falconer to come to the conclusion that these strata are of Pliocene date, and Mr. Prestwich to believe that they belong to a late stage in the Pleistocene\*.

The same group of animals, with the exception of the Megarhine and Tichorhine Rhinoceros and the Musk-sheep, is furnished by the fluviatile deposit at Clacton, in Essex, in association with the peculiar form of Fallow Deer which I have described under the name of *Cervus Browni*.

One of the most remarkable facts brought to light by Mr. McEnery is the former presence of the sabre-toothed Felis (*Machærodus latidens*) in the cave of Kent's Hole. Its characteristic canines are found associated with thousands of the teeth of Horse and Hyæna. Kent's Hole is the only place where this fell carnivore has been found along with the remains of Mammoth, Reindeer, and other Pleistocene mammals. It belongs to an archaic type, which sprang into existence during the Miocene times in France, Germany, and Switzerland, and preyed upon the Hipparion and Antelope in the plains of Marathon and on the Indian flanks of the Himalayas—to a type that coexisted with *Elephas meridionalis* and the Mastodon during Pliocene times in France, Germany, Britain, and Italy, and in South America preyed upon the gigantic Sloths and Horses whose remains are found in the Brazilian caves.

The large masses of breccia which occur in the cave-earth of Kent's Hole are remarkable for their hard crystalline structure, and prove that there was a stalagmite floor in the cave before the introduction of the earth, and long before the formation of the present stalagmite pavement. In a portion of the cave called the "gallery" there is evidence of the undisturbed part of this ancient stalagmite in a "ceiling, or uppermost floor," that extends from wall to wall, "without further support than that furnished by its own cohesion. Above it there is in the limestone-rock a considerable alcove. This branch of the cavern, therefore, is divided into three stories, or flats,—that below the floor occupied with cave-earth, that between the floor and ceiling entirely unoccupied, and that above the ceiling also without a deposit of any kind." From its being stained with cave-earth, as well as from its position, the ceiling, at the time of its deposition, must have been supported by cave-earth. It would, indeed, be as impossible for a solid horizontal sheet of stalagmite to be formed in mid

\* Falconer, Palæont. Mem.; Prestwich, Geol. Mag.

air as it would be for a sheet of ice to be formed without resting on water. From some cause or other this ancient stalagmite has been in part broken up, and the materials by which it was formerly supported have disappeared. That, however, even prior to its formation animals dwelt in the cave is proved by the bones which are imbedded in the large fallen masses. Moreover there is reason to believe that certain fragments of bone and splinters of teeth, remarkable for their mineralization, that have been found in the earth now occupying the cavern, were derived from this more ancient deposit; for they differ essentially from the remains with which they are now associated, being heavier and of a more crystalline structure. Some splinters have assumed the fracture of greensand chert. So hard indeed was one of the canines of Bear, that it has been splintered by the hand of man into the form of a flint-flake, and has evidently been used for a cutting-purpose. Its fracture proves that it was mineralized before it was splintered; and as it was found in the present cave-earth, it must have been fashioned while the cave was being inhabited by palæolithic man prior to the accumulation of the earth. For these reasons the evidence in favour of these denser remains having belonged to the deposit which once supported the ancient floor seems to me to be incontrovertible.

This view opens up an entirely new field for investigation as to the discovery of the *Machcerodus*; for it is very likely that this mammal may really belong to the older cave-earth, and not to the more modern, in which the remains of the Mammoth, Woolly Rhinoceros, and the like occur. But whether this be true or not, it adds a tenfold interest to the exploration of the cave, because there may be still left, in some nook or corner, masses of the older breccia, containing forms of life that had passed away before the arctic mammalia occupied the south of England.

The presence in the cave at Oreston\*, in the same district, of the Pliocene *Rhinoceros megarhinus* (an animal which has never yet been met with in any of the Late Pleistocene caves or river-deposits) strengthens the conclusion that some of the caves in the south of England may contain a fauna that was living before the Late Pleistocene age.

Both these caves were probably occupied by the wild beasts for a very considerable length of time; and the remains left behind after each occupation would be extremely likely to be mixed up together, by the passage of water through the chambers, during the oscillations of level which undoubtedly took place during the Pleistocene age. Proof of such oscillations in the south of England is afforded by the submerged forest-bed of Bracklesham, in Sussex, which is covered over by a deposit of Boulder-clay and ancient marine shingle. This explanation of their presence seems to me to be more probable than the assumption that they were living during the later Pleistocene period in that area; for in that case their remains would be more commonly met with in the many caves of the south of England, as well as in those of the Late Pleistocene age in

\* Quart. Journ. Geol. Soc. vol. xxvi. p. 457.



the South of France, where the proximity of the Mediterranean must have caused the temperature to be higher than in the north of France and Britain.

The evidence that Kent's Hole and Brixham Cavern had, at one time, been occupied by an accumulation of cave-earth and stones, which were sealed down with a coating of stalagmite, and that this was subsequently destroyed before either was filled with the deposits which it now contains, is clear and decisive.

During the Middle Pleistocene in the Thames valley, and at Clacton, the Woolly Rhinoceros, Elephant and Mammoth, competed for the same feeding-grounds with *Rhinoceros hemiteochus*, *R. megarhinus*, Hippopotamus, and *Elephas antiquus*. Although all the characteristic Pliocene Cervidæ had retreated, the Reindeer had not yet invaded that area: it was occupied by the Stag, the Roe, the Irish Elk, and *Cervus Browni*. The whole assemblage of animals, the Musk-sheep being excepted, implies that the climate was, at this time, less severe than when the Reindeer spread over the same area in the Late Pleistocene times, and was far more numerous than the Stag. It may, indeed, be objected that the classificatory value of the Musk-sheep is quite as great as that of *Rhinoceros megarhinus*; but in the case of the lower Brick-earths, the evidence of the latter as to climate agrees with that of the whole assemblage of animals, while that of the former is altogether discordant.

#### 6. THE EARLY PLEISTOCENE MAMMALIA.

The fossil mammalia must now be examined which inhabited Great Britain during the Early Pleistocene period, and before the maximum severity of glacial cold had as yet been reached. The fossil bones from the forest-bed which underlies the Boulder-clay on the shores of Norfolk and Suffolk, have for many years attracted the attention of naturalists and geologists. The magnificent collections of the Rev. John Gunn and the late Rev. S. W. King gave Dr. Falconer the means of proving that the fauna of that ancient submerged forest differed from that of any geological period which we have hitherto discussed. And the careful diagnosis of all the fossils from this horizon which I have been able to meet with, shows that it was of a very peculiar character, being closely allied to the Pliocene of the south of France and of Italy, and yet possessing species which are undoubtedly Pleistocene. The following list is necessarily very imperfect, since the fragmentary nature of the fossils renders a specific identification very hazardous; and it only includes those which I have been able to identify with any degree of certainty.

Sorex moschatus.	Machærodus.	Hippopotamus major.
— vulgaris.	Cervus megaceros.	Sus scrofa.
Talpa europæa.	— capreolus.	Equus caballus.
Trogontherium Cuvieri.	— elaphus.	Rhinoceros etruscus.
Castor fiber.	— Polignacus.	— megarhinus.
Ursus spelæus.	— carnutorum.	Elephas meridionalis.
— arvernensis.	— verticornis.	— antiquus.
Canis lupus.	— Sedgwickii.	— primigenius.
— vulpes.	Bos primigenius.	

From the examination of this list, the peculiar mixture of Pliocene and Pleistocene species is evident. The *Ursus arvernensis*, *Cervus Polignacus*, *Hippopotamus major*, *Rhinoceros etruscus*, and *R. megarhinus*, the Horse, *Elephas meridionalis*, and *E. antiquus* were living in the Pliocene age in France and Italy, and probably in Norfolk. The Cave-bear, the Wolf, Fox, Mole, Beaver, Irish Elk, Roe, Stag, Urus and Wild Boar, and the Mammoth have not as yet been discovered in the Continental Pliocenes, as judged by the standards offered by the Val d'Arno and Southern France, and are more or less abundant in the late Pleistocene age. This singular association seems to me to imply that the Forest-bed fauna is intermediate between the two and, from the fact that only three out of the whole series, viz. *Ursus arvernensis*, *Rhinoceros etruscus*, and *Cervus Polignacus*, are peculiar to the Continental Pliocene, that it is more closely allied to the Pleistocene than to the Pliocene.

It is also very probable that this early Pleistocene age was of considerable duration; for in it we find at least two forms (and the number will probably be very largely increased) which are unknown in Continental Europe, although Pliocene and Pleistocene strata have been diligently examined in France and Germany. The very presence of the *Cervus Sedgwickii* and *C. verticornis* implies that the lapse of time was sufficiently great to allow of the evolution of forms of animal life hitherto unknown, and which disappeared before the middle and late Pleistocene stages. The *Trogontherium* also, as well as the *Cervus carnutorum*, both of which occur in the forest-bed and in the gravel-beds of St.-Prest, near Chartres, and which are peculiar to this horizon, point to the same conclusion.

The Cervidæ of the forest-bed, in this list, do not represent approximately the number of species: there are at least five, and perhaps six, represented by a series of antlers, which I do not venture to quote, because I have not been able to compare them with those of the Pliocenes of the Val d'Arno, of Marseilles, or of Auvergne.

Dr. Falconer pointed out that one of the peculiar characters of the fauna of the forest-bed is the presence of the Mammoth; and the evidence on which he considered the animal to be of Preglacial age in Europe has been fully verified by the molars from Bacton, which are now in the Manchester Museum. They were associated with *Elephas meridionalis* and *E. antiquus*, and are incrustated with precisely the same matrix as the teeth and bones of those species.

#### 7. M. LARTET'S CLASSIFICATION.

Before we proceed to the examination of the Pleistocene Mammalia of the Continent it will be necessary to ascertain the value of the received classification.

The late M. Lartet proposed in 1861 (*Ann. des Sciences Nat. Zool.* 1861, p. 217) the following chronological divisions of the Quaternary or Palæolithic age, or that which corresponds with the late Pleistocene. Acting on the *à priori* consideration that all the animals found in the caves and river-deposits of France did not invade Europe at one time,

but successively, he has attempted to give the true sequence of the invasion, and assigns all the French caves and river-deposits to "l'âge du grand ours des cavernes, l'âge de l'éléphant et du rhinocéros, l'âge du renne, et l'âge de l'aurochs." It seems to me that there are several fatal objections to this very generally received classification. It is necessary, in the first place, to show which of these animals came here first, before we can say that the age of the Cave-bear preceded that of the Mammoth, or the age of the Mammoth that of the Reindeer, or lastly, the age of the Reindeer that of the Aurochs. We must know for certain that this was the true order of their advent; and of this M. Lartet has not advanced any satisfactory proof. It is certainly true that the Mammoth was in occupation of the Thames valley and of the area which is now covered by the German Ocean before the Reindeer had arrived. That this must necessarily have been the case follows from the fact that the former is a less arctic animal than the latter—being found in the forest-bed of Norfolk, which is proved by its vegetation to have been accumulated under temperate conditions, as well as in company with the Mastodon in the lower basin of the Mississippi. As the evidence stands at present, the Mammoth occupied the same area as the Cave-bear in the Early Pleistocene times, and is as clearly entitled to the first place in classification as the latter animal. If we consider the conditions under which the Pleistocene mammalia invaded Pliocene Europe, we can see at once why the Mammoth preceded the Reindeer. The temperate climate gradually became colder in France, Germany and Britain; and as the cold became more intense in the northern portions, the animals fitted for a cold climate passed southwards and westwards. In this great migration the animals adapted for a temperate or moderately severe climate would be the first to arrive. Were the climate of the extreme north to become so intense as to prevent the sojourn of the Reindeer and Musk-sheep on the shores of the Arctic Ocean, and to affect the whole of the Continent, there would be a steady drift of mammal life from north to south; the Elk and the Wapiti would invade the country of the Bisons, and leave their own district to be occupied by the Reindeer and the Musk-sheep. Indeed, speaking roughly, the zones of animal life which are centred round the north would not alter their relative position, but would be pushed further south, as it were, *en masse*. If the severity increased, the Reindeer would eventually reach the country of the Bisons, but only to find it in possession of the rearguard of Elks. From this analogy it follows that the animals which are now living in the temperate regions and which lived in Pleistocene Europe, arrived before their more arctic fellow immigrants. And if this be admitted, the Mammoth, the Irish Elk, and the Aurochs are at least as fairly entitled to occupy the first place in classification as the Cave-bear. In Britain the first of these animals has been obtained from the Forest-bed, as well as the Cave-bear, and is therefore of precisely the same relative antiquity. The foreign strata offer no evidence on this point.

A second objection to this theory is to be found in the fact that it



presupposes that every collection of fossils found in a cave or river-deposit is likely to furnish a complete set of the animals living in the country at the time. The den of an Hyæna could hardly be expected to afford the same animals as those which are found in river-deposits; and the abode of a Cave-bear would most certainly contain a different suite of remains. If indeed the present distribution of animals be any clue to that of the Pleistocene, the very diversity which M. Lartet insists upon as representing different periods of time must necessarily have resulted from the same country being occupied by different animals at the same time. The Bear and Hyæna were living in the caves at the same time that the neighbouring river-valleys were occupied by the Mammoth, the Reindeer, and the Aurochs. Nor indeed does the classification apply even to the few cases on which the generalization is based. That of Aurignac\*, for instance, is referred to the period of the Cave-bear, although the Reindeer, Mammoth, and Aurochs are also present. The caves of the Dordogne†, which have furnished such wonderful traces of the civilization of the hunter during those ancient times, are considered to belong to the Reindeer age, although the Mammoth has been found in no less than four out of the same series. A study of the distribution of these animals through the caves of France, Britain, and Germany has convinced me that three out of the four are worthless for the purpose of classification, since in the great majority of cases the four animals are associated together in the caves, and very generally also three out of the four in the river-deposits. And although the evidence seems pretty clear that the Reindeer arrived in Europe after these three animals, it competed with them for a very long time in the same area. As, also, the arctic climate gradually became temperate, it ought, *à priori*, to have been the first to retreat northwards, leaving the three others behind—the Aurochs to survive in the forests of Lithuania, and the other two to become extinct. We have no proof as to which of these became extinct first. The climatal change which was sufficient to banish the Reindeer from the south of France and from Central Germany had certainly not taken place during the latest stage of the Pleistocene; and the occurrence of that animal in the peat under the alluvium of the Thames, at Crossness, proves that it lived as far south as Kent in the Prehistoric age. In all probability, during some part of the vast interval which exists between the Pleistocene and the Prehistoric periods, it had become extinct in Central and Southern Europe, since it has not been discovered in any deposits in those regions which can be referred to the latter period. For these reasons M. Lartet's generalizations seem to me to be untenable, although it be true that the Cave-bear, Mammoth, and Aurochs arrived in Europe before the Reindeer, and the last-named animal departed from France and Germany before the Aurochs.

\* See Ann. des Sc. Nat. Zool. 1861, p. 213.

† The materials for coming to a conclusion as to the Mammalia of Périgord have been afforded by the 'Reliquiæ Aquitanicæ' and the "Cavernes du Périgord" (Revue Archéol., Avril 1864), by M. Ed. Lartet and H. Christy, and by the examination of some of the remains in the Christy Museum.



Dr. Hamy\* practically admits this to be the case when he follows Sir John Lubbock in classifying the caverns and river-deposits by the presence of the Cave-bear and Mammoth on the one hand, and of the Reindeer on the other, and by accommodating the theory to the facts by a series of transitions. But even his modification of M. Lartet's views does not explain the facts; for the "Station of Moustier," which he takes as the type of the series belonging to the age of the Mammoth, furnishes remains of the Reindeer, and those of Langerie Haute and Langerie Basse, which he refers to the age of the Reindeer, contain the Mammoth.

M. Dupont's† division of the caves of Belgium into the ages of the Mammoth and the Reindeer is equally unsatisfactory. In the Trou de Sureau, for instance, which he assigns to the former age, one Mammoth and many Reindeer were found; and in the other caves, which he assigns to the same date, more individuals were discovered of the Reindeer than of the Mammoth. In the Trou de Chaleux, which is referred to the later age, the Mammoth is found as well as the Reindeer.

Our present imperfect knowledge renders it impossible to subdivide the latest stage of the Pleistocene by means of the Mammalia, although the archæologists may be able to establish a rude sequence based on a comparison of the implements and weapons found in caves and the deposits of rivers. This principle of classification by the relative rudeness of such remains presupposes that the progress of man had been gradual, and that the rudest implements and weapons are the oldest. The difference, however, may have been due to different tribes or families having lived at the same time without intercourse with each other, as is now generally the case with savage communities, or to the supply of flint and chert for cutting-instruments being greater in one region than in another.

#### 8. RANGE OF LATE PLEISTOCENE MAMMALIA ON THE CONTINENT.

The latest of the three divisions of the British Pleistocene fauna is widely spread throughout France and Germany and Central Russia. In the former country it has been proved by MM. Marcel de Serres, Lartet, Gaudry, Gervais‡, and others to have ranged from the English Channel to the shores of the Mediterranean, the only remains which have not been discovered in Britain being the Marmot, Chamois, Ibex, *Antelope saiga*, and striped Hyæna. In the following Table I have selected a few typical cases to show how the animals are associated together in various parts of France, Belgium, and Germany; and I have added those which have been discovered in

\* Précis de Paléontologie Humaine, par le docteur G. T. Hamy, 8vo, Paris, 1870. Tableau I.

† Les temps Antéhistoriques en Belgique. L'Homme pendant les âges de la pierre. Par M. E. Dupont, 8vo, Bruxelles, 1871.

‡ M. de Serres, 'Les Oss. Foss. des Cavernes de Lunel Viel,' 4to. M. Lartet, *op. cit.* and 'La Seine,' par M. Belgrand, t. ii. 4to, 1871. M. Gaudry, a letter to the author; see also "Matériaux pour l'Histoire de l'Homme." M. Gervais, Zool. & Paléont. Françaises, 2nd edit., 4to, 1859; Nouvelles Recherches sur les animaux vertébrés, 4to, 1867-69.

FRANCE.

	Seine; Somme; River-deposits.	Grotte de la Combe Granal.	Grotte de Puy de l'Aze.	Grotte du Moustier.	Grotte des Eyzies.	Station de Langerie Haute.	Station de Langerie Basse.	Aurignac.	Provence.	Nice; Mentone.	Mars; Hérault.	Lunel Viel.
<i>Homo palæolithicus</i> ..	*	*	*	*	*	*	*	*			*	
<i>Spermophilus citillus</i> ..								*			*	
<i>Areomys marmotta</i> ..										*	*	
<i>Castor fiber</i> ..	*										*	*
<i>Lepus timidus</i> ..			*					*			*	
— <i>variabilis</i> ..												
— <i>cuniculus</i> ..		*	*									
— <i>diluvianus</i> ..												*
<i>Lagomys pusillus</i> ..									*			
<i>Mus lemmus</i> ..												
<i>Hystrix dorsata</i> ..									*			
<i>Felis leo</i> (var. <i>spelæa</i> ) ..	*			*				*	*			*
— <i>pardus</i> ..											*	*
— <i>lynx</i> ..										*		*
— <i>caffer</i> ..												*
— <i>catus</i> ..												*
— <i>pardina</i> ..												*
— <i>serval</i> ..												
<i>Gulo borealis</i> ..												
<i>Hyæna crocuta</i> (var. <i>spelæa</i> ) ..	*		*					*	*	*		*
— <i>striata</i> ..												*
<i>Mustela martes</i> ..												
— <i>putorius</i> ..												*
— <i>erminea</i> ..												
<i>Lutra vulgaris</i> ..	*											
<i>Ursus arctos</i> ..	*											
— <i>ferox</i> ..											*	
— <i>spelæus</i> ..			*							*		*
<i>Canis lupus</i> ..	*	*	*				*	*		*	*	*
— <i>vulpes</i> ..	*	*	*				*	*		*	*	*
— <i>lagopus</i> ..												
<i>Elephas primigenius</i> ..	*		*	*		*	*	*				
— <i>antiquus</i> ..	*								*			
— <i>africanus</i> ..												
<i>Equus caballus</i> ..	*	*	*		*	*	*	*		*		*
<i>Rhinoceros tichorhinus</i> ..	*							*				
— <i>hemitechus</i> ..	*								*	*		*
— <i>megarhinus</i> ..												
<i>Bos urus</i> ..	*	?	?		?	?	?	?	*	?		*
— <i>bison</i> ..	*	*	*		*	*	*	*				
<i>Ovibos moschatus</i> ..	*											
<i>Capra ibex</i> ..		*	*					*		*		
<i>Capella rupicapra</i> ..		*			*	*	*					
<i>Antilope saiga</i> † ..												
<i>Sus scrofa</i> ..	*	*	*					*	*			*
<i>Cervus elaphus</i> ..	*	*	*					*	*	*		*
— <i>capreolus</i> ..	*							*		*		
— <i>megaceros</i> ..	*					*	*	*		*		
— <i>tarandus</i> ..	*		*	*	*	*	*	*				
— <i>dama</i> ..												
<i>Hippopotamus amphibi-</i> <i>bius</i> (var. <i>major</i> ) ... }	*											
— <i>Pentlandi</i> ..												

† *Antilope saiga* has been found

MAMMALIA ON THE CONTINENT.

BELGIUM.										PLEISTOCENE MAMMALIA.									
Caves of Selmerling.	Trou de Magrite.	Trou de Sureau.	Trou de Naulette.	Trou de Chaleux.	Trou de Nutons.	Suabia.	Switzerland.	Prussia.	Bavaria: Galenreuth.	Spain.	Gibraltar.	Italy: Val di Chiana, Rome.	Sicily.						
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?	?	?	?	?	?	?	?	?	?	?	?	?	?						
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in the cave of Bruniquel.

the areas south of the Alps and Pyrenees which cannot with any certainty be said to belong to one stage of the Pleistocene rather than to the other. The *Antilope saiga* has been added to the list of the French Mammalia by M. Lartet from remains found in the cave of Bruniquel. The caves of Mentone, explored by Mr. Moggeridge\*, and the caves and river-deposits of Provence are remarkable for the absence of the Reindeer, which is so abundant in those of the Pyrenees.

The same group† of animals has been proved to have occupied Belgium by the researches of Dr. Schmerling and M. Dupont; while their range is extended into Suabia by the investigations of Prof. O. Fraas, and into Switzerland by Dr. Rüttimeyer. They also passed eastwards, and are found in the caves of Bavaria; and the more characteristic forms (such as the Mammoth, Woolly Rhinoceros, Musk-sheep, Reindeer, and Bison) have been traced through Russia in Europe by Pallas, into Northern Asia, where they have been met with in vast abundance by many explorers‡.

#### 9. THE MIDDLE PLEISTOCENE.

The middle division of the Pleistocene, or that stage which is represented in Britain by the older deposit in Kent's Hole and the brick-earth of the Thames valley, is represented by a river-deposit in the Auvergne, which contains *Machærodus latidens*, and the cave of Baume, in the Jura, in which *Machærodus* occurs in association with the Cave-bear, Hyæna, Elephant, and a non-tichorine species of Rhinoceros. The distinctness of *M. latidens* from any of the Pliocene species has been satisfactorily decided by Prof. Gervais. The animal may therefore be taken as characteristic of a non-Pliocene era in the history of the animals of Europe; and since, on the one hand, the entire Arctic group of animals, so characteristic of the Late Pleistocene stage, is absent, and, on the other, all the peculiar animals of the early stage represented by the Forest-bed, that era must be Middle Pleistocene §.

#### 10. THE EARLY PLEISTOCENE DIVISION.

The river-deposit of St.-Prest, near Chartres, represents in France, according to Prof. Gervais, the Early Pleistocene stage of the Forest-

\* Brit. Assoc. Meeting 1871, Edinburgh; Congrès International d'Anthropologie & d'Archéologie préhistoriques, Paris, volume for 1867, p. 96.

† The authorities for this list are the following writers:—For France and Belgium, those which have been quoted, Lartet, Christy, Gervais, Gaudry, De Serres. For those of Belgium, Dr. Schmerling, 'Les Oss. Foss. des Cavernes de Liège.' Suabia: Dr. Fraas. Switzerland: Dr. Rüttimeyer. Prussia: Sir Charles Lyell, 'Antiquity of Man;' Giebel 'Palæontologie,' Quedlinburg, 1851, p. 32. Spain: M. Lartet, 'Ann. des Sc. Nat.' Gibraltar, Italy, Sicily: Falconer, 'Palæont. Memoirs,' vol. ii.; Busk, 'Prehistoric Congress,' Norwich, 1868.

‡ Middendorff, 'Sibirische Reise.' Wrangel, 'Siberia and the Polar Sea,' transl. by Major Sabine, 1840.

§ The authorities for this paragraph are:—Gervais, 'Zool. et Paléont. Franç., article *Machærodus*;' 'Animaux vertébr.' 1867-69, p. 76; Lartet, 'Congrès International d'Anthropologie et d'Archéologie préhistoriques,' Paris, p. 269.



bed in this country. It contains the *Cervus carnutorum* and *Trogontherium Cuvieri*, in association with the Pliocene *Rhinoceros etruscus* and *Elephas meridionalis*, the two former of which are peculiar to it and the forest-bed. Although, therefore, there is no trace that any of the Northern Asiatic animals had yet arrived in Europe, the group most probably belongs to the early Pleistocene, since it is characterized by the presence of two non-Pliocene animals\*.

#### 11. PLEISTOCENE FAUNA OF SOUTHERN EUROPE.

The fauna of Italy and Spain is remarkable for the absence of the Arctic forms which were so abundant in Central France and Germany; and there is no doubt that the difference between the fauna of the region north of the Alps and Pyrenees and that of the south is due to a difference of latitude and to the fact that the climatal change so marked in the north was hardly felt in the south. In other words, the physical condition of Britain during the early stage of the Pleistocene, and which did not recur again, was maintained throughout the Pleistocene period in the districts above mentioned. It is therefore no wonder that in the Pleistocenes of Italy we find the Mammoth associated with *Rhinoceros etruscus*, *R. megarhinus*, *Elephas antiquus*, and the Hippopotamus in the valley of the Tiber, and in the Val di Chiana with the Urus, Bison, and Irish Elk, just as in the Forest-bed of Norfolk †. But it does not follow from this that the Italian deposits are synchronous with the Forest-bed; for it is almost certain that, while the arctic mammalia were invading North-eastern Europe and had taken possession of Britain and the north of France, the Pliocene fauna of the south was scarcely affected; and it is reasonable to suppose that, even while the climate of Europe was lowered to the utmost in the Glacial period, the cold was not sufficient to allow of the invasion of the southern latitudes by the Arctic group of mammalia. The same observation applies also to Spain, in which M. Lartet has identified the African Elephant and the Striped Hyæna, as well as palæolithic implements, near Madrid.

The explorations of Capt. Broome ‡ in the caves of Gibraltar prove that the Grizzly Bear, Spotted Hyæna, Panther, *Rhinoceros hemitoechus*, Ibex, and many other animals mentioned in the above list lived in the Iberian peninsula during the Pleistocene age. In both Italy and Spain at that time the facies of the animal life was southern, and was not subject to those changes which are observable in Britain and France.

#### *Fauna of Sicily, Malta, and Crete.*

The investigations of Dr. Falconer § in the caves which occur in

\* Lartet, 'La Seine,' par M. Belgrand, vol. ii. p. 206. Gervais, 'Animaux vertébrés vivants et fossiles,' 4to, 1867-69, p. 32.

† Falconer, 'Palæont. Memoirs,' vol. ii. p. 242.

‡ 'International Congress of Prehistoric Archæology,' Norwich, 1868, p. 106; Quart. Journ. Geol. Soc. vol. xxi. p. 364.

§ Quart. Journ. Geol. Soc. vol. xvi. p. 99; Palæont. Memoirs, vol. ii. p. 545.

the Hippurite limestone near Palermo, in Sicily, show that the Mammoth, which ranged as far south as the valley of the Tiber, did not cross the straits of Messina into Sicily. In the Grotto di San Ciro and in the Grotto di Maccagnone, from which vast quantities of bones have been exported from time to time for use in sugar-refining, a fauna was discovered differing in most important respects from that which has been described. Although the *Elephas antiquus* and the Spotted Hyæna remind us of the like deposits in the caves of Gower or Kirkdale, they were associated with the African Elephant and a small extinct Hippopotamus (*H. Pentlandi*). The last-named animal has been discovered by Dr. Adams and Captain Spratt\* in the caves of Malta, along with a gigantic Dormouse (*Myoxus melitensis*) and two pigmy Elephants (*E. melitensis*). It has also been identified by Dr. Falconer† in the island of Candia. There is also proof of its having lived on the mainland of Greece, since an upper true molar, discovered by Dr. Rolleston, F.R.S., in a Greek tomb near Megalopolis in 1871, certainly belongs to this species, and was most probably obtained from one of the many caves which traverse the limestone plateau of Greece.

## 12. THE PLEISTOCENE CLIMATE.

We have now to consider the conditions under which such an extraordinary fauna as this lived in Europe during the Pleistocene times; and the inquiry will lead us into some very interesting problems relating to the ancient climate and geography. The Pleistocene mammalia may be divided into five well-marked groups:—the first embracing those which live now in hot countries; the second those which inhabit northern regions or the tops of lofty mountains, where the cold is severe; the third those which inhabit temperate regions; a fourth those which are found alike in cold and hot; and a fifth those which are extinct.

### *The Southern Group of Animals.*

The group of Pleistocene animals now found only in southern climates consists of eight. At the present day the Lion is found, with but extremely slight variations, in the whole of Africa—with the exception of Egypt and the Cape Colony, from which it has been driven by the hand of man. In Asia the maneless variety inhabits the valley of the Tigris and of the Euphrates and the districts bordering on the Persian Gulf; and in India the common form is met with, according to Mr. Blyth, in the province of Kattywar, in Guzerat. Although the animal is now found only in these hot regions, it is proved by the concurrent testimony of Aristotle, Pausanias, and Ælian to have inhabited the mountains of Thrace, in which the winter cold must have been severe. The animal, therefore, although from its present distribution better fitted for a tropical than a temperate climate, possessed suffi-

\* Falconer, Palæont. Memoirs, vol. ii. p. 299. Spratt, Quart. Journ. Geol. Soc. vol. xxiii. p. 283. Leith Adams, Journ. Roy. Dubl. Soc. 1863.

† Palæont. Memoirs, vol. ii. p. 553.

cient elasticity of constitution to endure a considerable degree of cold. The second animal belonging to this section, the Spotted Hyæna, is now found only in South Africa, under tropical conditions; while the third, or the Hippopotamus, lives at the present time in Middle and Southern Africa. Formerly it inhabited the valley of the lower Nile; and a tooth in the British Museum, from Nubia, is as large as that of the fossil variety, *H. major*. In the Pleistocene period it extended over the whole of the regions north of the Mediterranean, from Sicily and Gibraltar as far as Kirkdale, in Yorkshire, and eastwards into the valley of the Rhine; and the Hyæna and Lion at least as far to the west as Hungary, and to the north as Königsberg. The evidence afforded by these three animals as to the climate of those portions of Europe which they inhabited in Pleistocene times, differs considerably in point of value, but, on the whole, points towards a temperate or comparatively hot condition; for, although the elasticity of constitution which we know to have been possessed by the Lion may also have been shared by the Hyæna, it is very improbable that so aquatic an animal as the Hippopotamus could have ranged from Southern Europe as far north as Yorkshire under any other than temperate conditions. It could hardly have endured a winter sufficiently severe to cover the rivers with a thick coating of ice, without having its habits entirely altered; and such an alteration of habit would certainly leave its mark in other modifications in the fossil remains than those minute differences which have been observed between them and the skeleton of the living *Hippopotamus amphibius*. The fourth species, or the African Elephant, ranged as far as Sicily, and, according to M. Lartet, as far in Spain as Madrid. The fifth, or the Striped Hyæna, so common now in North Africa, has, according to the same high authority, been discovered in Spain and, by M. de Serres, in the cave of Lunel Viel, in the south of France; and the *Felis caffer* of Desmarest, an African species, has been added, by Mr. Ayshford Sanford and the writer, to the British animals. The Serval and *Felis pardina* of Africa have been identified by Dr. Falconer and Prof. Busk among the remains from the caves of Gibraltar\*.

#### *The Northern Group.*

The second group consists of those which are now only to be met with in the colder regions of the northern hemisphere—the Glutton, the Reindeer, Musk-sheep, Pouched Marmot, Hamster, Alpine Hare, Lemming, Ibex, and the Chamois; and their testimony as to climate is diametrically opposed to that of the preceding eight animals. The Musk-sheep, now found only in the high latitudes of the North-American continent, on the desolate, treeless, barren grounds, and the Reindeer, which lives in the belt of forest and the great treeless plains which extend between the forest and the sea, ranged through North Germany, Britain, and France, as far south as the mountain-barriers of the Alps and Pyrenees. Their absence from the districts further to the south is due, most probably, to a difference in tempe-

\* Since the above was written, Professor Busk has informed me that he has detected *Felis caffer* among the remains from Gibraltar.



rature, rather than to an insurmountable mountain-range, since they are absent from Provence and Nice, on the French side of the Alpine barrier. The Pouched Marmot (*Spermophilus citillus*) of the Don and Volga, found its way as far west as Somersetshire; and the Hamster of Siberia extended as far west as Provence. The Alpine Hare, now found only in the colder climates of Northern Europe (with the solitary exception of Ireland), occupied the valley of the Rhine, at least as far down as Schussenried, in Suabia; and the Alpine Marmot lived then as now on the shores of the Mediterranean, near Mentone. The Ibex and Chamois ranged throughout Germany, as far north as Belgium, and occupied the south of France; and the former ranged as far to the south as Mentone and Gibraltar. The two carnivores now characteristic of the arctic regions, the Glutton and the Arctic Fox, have been discovered, the one as far to the south-west as Eastern France\*, and the other as far as Schussenried; and at one time they doubtless occupied the whole of Germany and Northern Russia. The latter has not been found either in Britain or France. If the present habits of these animals be any index to their mode of life in the Pleistocene age, their presence in France, Germany, and Britain implies that the climate was severe, that it must have been analogous to that which they now enjoy on the tops of lofty mountains, or in the severe climate of the northern steppes in Asia and the high northern latitudes of America. But this conclusion is diametrically opposed by the evidence afforded by the Lion, Hippopotamus, and Spotted Hyæna. On the one hand, we meet with a group of animals throughout Italy and Spain and passing as far north as the latitude of Yorkshire, which are now peculiar to hot climates; on the other hand, we have a group of animals peculiar to cold climates, occupying in full force the whole of the region north of the Alps and Pyrenees. And the remains of these two groups of animals are so associated together in the caves and river-deposits of this region, that it is impossible to deny the fact that it was the common feeding-ground of both. And although it may be objected that the Spotted Hyæna, Lion, and *Felis caffer* may have been endowed with the same elasticity of constitution as the living Tiger, which is equally fitted to endure the severity of a Siberian winter on the shores of the Sea of Aral, and the intense tropical heat of Bengal, the same objection cannot be made to the Hippopotamus, because there is no case on record of any living species of herbivore being fitted at once for a cold and a hot climate.

The difficulty, however, offered by this conflict of testimony vanishes away, if we examine the conditions under which animals migrate from one area to another, according to the season. Sir John Franklin writes that the migrations of the animals in North America afford a means of foretelling the severity of the season. If the Reindeer retreat far south, then a severe winter is to be apprehended; if, on the contrary, they remain very nearly in their usual winter haunts, the season invariably is a mild one. The Reindeer of Northern

\* Hamy, Paléontologie Humaine, p. 152.



Russia are equally dependent upon the season for their locality; and if an unusual season occurs, to put the animals off their accustomed route, the inhabitants of the district at the mouth of the Kolyma, living upon the chase, endure the severity of famine. M. von Matiuskin, the lieutenant of Admiral von Wrangel, had the good fortune to see one of the migratory bodies of Reindeer, consisting of many thousands divided into herds of two or three hundred each, in the act of crossing a river. By some such oscillation of temperature which regulates the supply of food for the herbivores, the remains of the animals of two contiguous zoological provinces may be found together in one spot, as in the case of the northward retreat of the Musk-sheep, which, living in Hearne's time (A.D. 1770) near Fort Churchill, has left that district to be occupied now by the Elk and Wapiti. In this manner the admixture of the remains of animals living at the present day respectively in a severe and in a temperate continental climate may be accounted for in the Pleistocene caverns and brick-earths. Sir John Richardson writes:—"The subsoil north of lat.  $50^{\circ}$  is perpetually frozen, the thaw on the coast not penetrating above 3 feet, and at Great Bear Lake, in lat.  $64^{\circ}$ , not more than 20 inches. The frozen substratum does not of itself destroy vegetable life; for forests flourish on the surface at a distance from the coast, and the brief, though warm, summer gives birth to a handsome flora, matures several pleasant fruits, and produces many carices and grasses." The climatal extremes of temperature are very great, the minimum winter temperature at Fort Reliance, on the northern shore of the Great Slave Lake (N. lat.  $62^{\circ}50''$ , long.  $109^{\circ}$  W.) being registered by Capt. Back, 17th Jan. 1834, as being  $-70^{\circ}$ , and the maximum at the end of May  $+106^{\circ}$ . These observations are confirmed by those of Sir John Franklin, at Fort Franklin (lat.  $65^{\circ}$ , long.  $123^{\circ}$ ), where, on Dec. 25, 1826, the temperature was  $-43^{\circ}$ , and on the 31st May  $+93^{\circ}$ . Such a great variation as this could not have happened in the latitude of Britain, France, or Germany; nor is it required by the circumstances of the case.

In the vast plains of Siberia also, extending from the Altai Mountains to the Arctic Sea, we find a near approach to the Pleistocene climate of North-western and Central Europe. Covered by impenetrable forests, for the most part of birch, poplar, larch, and pine, and, in the north, of low creeping dwarf cedars, they present every gradation in climate, from the temperate to that in which the cold is too severe to admit of the growth of trees, which decrease in size as the traveller advances northwards, and are finally replaced by the grey mosses and lichens that cover the low marshy tundras. The minimum temperature registered by Admiral von Wrangel at Nishne Kolynisk on the banks of the Kolyma is  $-65^{\circ}$  in January. "Then breathing becomes difficult, the wild Reindeer, that citizen of the polar region, withdraws to the deepest thicket of the forest, and stands there motionless, as if deprived of life, and trees burst asunder from the intensity of the cold. Throughout this area roam Elks, Black Bears, Foxes, Sables, and Wolves, that afford subsistence to the Jakutian and Tungusian hunters. In the northern part countless herds of

Reindeer, Elks, Foxes and Wolverines make up for the poverty of vegetation by the rich abundance of animal life. Enormous flights of Swans, Geese, and Ducks arrive in the spring, and seek deserts, where they may moult and build their nests in safety. Ptarmigan run in troops among the bushes; little Snipes are busy among the brooks and in the morasses; the social crows seek the neighbourhood of new habitations; and when the sun shines in spring one may even sometimes hear the cheerful note of the Finch, and in autumn that of the Thrush." The hypothesis of a series of conditions in Europe, in Pleistocene times, similar to those of Northern Asia or of Northern America, would amply satisfy the difficulty of the case. In the Pleistocene winter the northern animals would pass southwards, and in the summer the southern forms would creep northwards; and to this swinging to and fro of the animals, according to the seasons, the peculiar intermixture of their remains, over what may be called the debatable ground of Central Europe, may be accounted for, the head quarters of the northern animals being to the south-east of a line drawn from Yorkshire and Königsberg, and the head quarters of the southern being the regions bordering the Mediterranean.

It must be borne in mind that this mode of explaining the intimate association of the mammalia of the north and south, in the same deposit of the same river, does not imply that in one season a migration took place from the head quarters of each of these groups to the extreme point to which the remains of the animals of which it is composed occur, such as the Hippopotamus from the Mediterranean as far north as Kirkdale, or the Reindeer from the north as far south as the Alps. In the secular lowering of the temperature, the northern animals would compete with the southern for their feeding-grounds, according to the season. And this competition, if the climatal conditions were stationary, might be carried on, over a very small area, for a very long time—the debatable ground being a narrow band between the invaders and the animals in possession. There were probably many such pauses. Nor does it imply that there were no reversions to a warm, or temperate, state after the glacial conditions had begun in Northern Europe. One such reversion at least is proved by the physical evidence to have taken place; but it has left no impression on the mammal fauna sufficiently marked for classificatory purposes. The Middle-Pleistocene mammalia may be the result of such a reversion, since the mixture of forms brought about by the southward advance of the northern animals would be the same as that of their retreat. The predominance of the northern over the southern animals in Central Europe implies that the winter cold during the Pleistocene age was more severe than it is now; and this conclusion is corroborated by the condition of the river-deposits in which they are found in France and Britain. The contortions of the gravels and the angularity of the pebbles are, according to Mr. Prestwich, only explicable on the theory of ice having been formed in our rivers in far larger quantities than at the present day. The large plateaux of brick-earths were probably deposited by floods, caused by the sudden melting of the winter

snow, similar to those which Admiral von Wrangel describes in Northern Siberia, and Sir John Franklin in the area north of the Canadian lakes.

The two other views which have been held as to the climate of the Pleistocene age must now be very briefly examined :—

1. Mr. Prestwich, fixing his attention more particularly on the evidence afforded by the contorted gravels and ice-borne pebbles in the river-deposits, has inferred that the climate was severe, and that the presence of the Hippopotamus in Britain may be accounted for on the hypothesis that it was clad in wool and hair, like the Mammoth. To this Sir John Lubbock objects that so aquatic an animal could not have lived here at the time that the rivers were frozen over. It seems to me also that such a change in the physique of the animal as Mr. Prestwich supposes could not have existed without leaving behind greater differences than we find between it and its living African representative. There were also other African animals in Britain, as well as the Hippopotamus.

2. The second view, or that of Sir John Lubbock and Mr. J. Geikie, accounts for the presence of arctic and African animals in Britain by the hypothesis that the one group occupied the country during a cold and the other during a hot period—in other words, that the swinging to and fro of the animal life depended upon secular, and not seasonal changes. Now, if this be true, we ought to find the remains of the animals in two distinct suites, in the river-deposits, corresponding to these climatal changes of long duration. We should find the Hippopotamus and Spotted Hyæna in those which were accumulated during the warm, the Reindeer, Glutton, and Marmot in those which were deposited in the cold period. After seeking for evidence of this for the last ten years, I cannot find the slightest trace of any such sequence in Britain or on the Continent. After the Pleistocene had fairly set in, as marked by the Forest-bed, and after the arctic mammalia had arrived, their remains are found lying side by side with those of the African species, *in the same river-strata*, and under the same physical conditions. Nor can this be accounted for by the supposition that the two series of remains have been accumulated at two *different* times, separated from one another by a wide interval—because in that case the one would be more decomposed than the other, or more rolled by water than the other. It is also a great demand on scientific faith to hold that in so many old river-deposits, as, for example, at Bedford, Acton Green, and Salisbury, the two series could by any possibility have been so intermingled as they actually are found to be, unless the animals to which they belong had been living at the same approximate time in the same region. This view is therefore untenable, so far as it is based on the false assumption that the remains occur in the river-strata in two distinct suites.

Mr. James Geikie, in a very able article in the 'Geological Magazine,' vol. ix. no. 4, brings forward the following objections to the view that the intermingling of the African with the Arctic species is due to climatal extremes :—



1. That the causes which induce the extremes of climate in the temperate zone of Northern Asia and America could not have existed in Britain. Before this objection can hold good, it is necessary to show what these causes are. Prevalence of wind in certain directions, writes Mr. Geikie (p. 166). This may be one of the causes; but at the same time it is one of the effects of change of temperature. The *vera causa* of the extremes in both cases seems to me to be that pointed out by Sir C. Lyell in the 12th chapter of the 'Principles' (1867)—the extension of a large mass of land from the equator to the polar circle. Such a mass of land extended from the range of Atlas northwards to the snowy regions of Scandinavia during the Pleistocene age (see Map, p. 436), the Mediterranean being reduced to two land-locked seas, and the mainland of Africa being continued on the one hand into Spain, and on the other, by Malta and Sicily, into Italy, and Greece extending so far south as to embrace Candia. Such an extent of land is surely an exact parallel to the two cases which I have quoted above; and climatal extremes must necessarily have been the result of the substitution of land for such a large area that is now covered by the sea. (See Map.) Mr. Geikie admits that at that time the winters were very much colder than they are now, because the higher mountains of Europe were also covered by *mers de glace*. Can he deny that the above geographical change in the Mediterranean area would have also left its mark in a higher summer temperature, other causes being put out of sight, than now? The inference that the summer temperature (p. 166) would be lower than at present in Britain, because there were glacier-areas in the north and in the higher districts in Central Europe, is inconclusive, since the mere existence of a glacier tells us nothing of the summer heat of the surrounding regions. Could we predicate, for instance, the temperature of the Subhimalayas from the contemplation of the glaciers of the central ridge? or the summer heat of Lombardy or of Provence from the glaciers of the Alps? Glaciers merely imply the existence of a certain line of mean annual temperature, *above* which the snow accumulates, and from which they are pushed down in some cases, as in New Zealand, to within a few hundred feet of the sea. It is obvious, therefore, that any argument from the Pleistocene glaciers to the summer heat is without value. All speculations as to the prevalent wind at that remote time in different parts of Europe appear to me mere guesses and nothing else.

2. The second objection is that the Hippopotamus is *not* a migratory animal. Is this so? It is true that its aquatic habits forbid its migration over the vast arid plains of Southern Africa, like the Antelopes; but, on the other hand, direct evidence for or against its migratory habits in a well-watered region is at present wanting. The remains found in Nubia, and preserved in the British Museum, certainly prove that once it ranged further north on the Nile than it does now. So far the evidence is in favour of its being a migratory animal. If its present range be compared with that during the Pleistocene it is impossible to deny that it *has* migrated from Africa to Yorkshire, or *vice versa*.



3. The third is that the Hippopotamus could not have traversed vast distances, say from the south of France to Kirkdale, in Yorkshire, in one season. So far from holding this view, I have always maintained that in the vast lapse of time represented by the Pleistocene, or, as Mr. J. Geikie, speaking merely from the point of view offered by Scotland, terms it, the "Glacial Period," every inch of ground in Middle Europe was fought over by the invading and retreating forms, not at *one* time, but at *successive* times.

4. To the fourth objection (p. 167), that, under the conditions of climate to which I have referred, the vegetation of Britain would have been too scanty and meagre for the support of the animals, and that the destructive floods would reduce the lower grounds to a desert at the break-up of the winter, it is only necessary to refer to Wrangel's 'Siberia,' Middendorf's 'Sibirische Reise,' and Sir John Franklin's 'Overland Journeys,' to prove the existence of a luxuriant forest-vegetation in the region extending in Middle Siberia south of the Tundras, and in that south of the Barren Grounds, and the fact that large floods in the spring do *not* destroy the vegetation.

5. A further objection is based on the presence in some cases of *Unio littoralis* and *Corbicula consobrina* along with the mammalia in the river-deposits. Can we predicate temperature from either of these shells? The former still lives in the Loire; and the latter is abundant in the beds of the streams in the region of the Himalayas. The evidence as to the existing range of both these mollusks does not seem to me sufficient to trace any conclusion as to Pleistocene temperature.

#### *The Temperate Group.*

The third group of Pleistocene mammalia (which still inhabits the temperate zones of Europe, Asia, and America (is far larger than either of the preceding which we have described. It contains the

Musk-Shrew.	Wild Cat.	Brown Bear.	Saiga Antelope.
Beaver.	Martens.	Grizzly Bear.	Stag.
Hare.	Ermine.	Horse.	Roe.
Rabbit.	Stoat.	Bison.	Fallow Deer.
Porcupine.	Otter.	Urus.	Wild Boar.

In the Pleistocene this group of animals had very much the same range over Europe as they have at the present time, although many of the species have retreated from their ancient homes. Thus the Grizzly Bear, which then ranged from the shores of the Mediterranean into Great Britain, Central Germany, and Belgium, has retreated to its present stronghold in the Rocky Mountains. And although, unlike its more arctic associate in France and Britain, the Musk-sheep, it has not been recognized in European Russia or in Northern Asia, there can be little doubt that its line of retreat was eastwards by the Straits of Behring. The *Antelope saiga*, which then passed as far to the west as Auvergne, and the Musk-shrew, which has been discovered at Bacton, are now only living in the warmer

regions of the Don and Volga, in Southern Russia. The latter animal is especially abundant on the banks of the Soura river, in lat. 55° N., and long. 47° E., under a temperate continental climate, cold in winter but hot in summer. Dr. Pallas, in his travels, describes the country which it inhabits as covered by tulips, saffron, and the Star of Bethlehem, in spite of the unusual severity of the preceding winter; and although the Pouched Marmot (*Spermophilus citillus*) was in the neighbourhood, there were vineyards close by. The Porcupine, on the other hand, does not now roam as far north as the caves of Belgium, but is restricted to the warmer countries near the Mediterranean.

The Pleistocene Urus still lives in the larger domestic cattle, although the wild breed was exterminated in the middle ages; and the Bison at the present time lives under the protection of the Tzar, in Lithuania, after having spread throughout Europe from Scania southwards. The Pleistocene Horse is represented by the mouse-coloured wild animal of Northern Asia; it was as abundant and as widely spread over the Pleistocene continent as the Urus and the Bison.

The presence of these animals in the Pleistocene fauna implies a climate not very severe, but in all probability resembling that of Southern Russia and Northern Asia, in which they now live.

#### *The Species common to Cold and Tropical Climates.*

The Panther, which has been found alike in Britain, France, and at Gibraltar, has at the present day a most extended range through Africa, from Barbary to the Cape of Good Hope, and throughout Persia into Siberia. In this latter country Dr. Gothilf Fischer describes it as living in the same districts in the Altai Mountains and in Soongaria as the Tiger. The Fox and Wolf are like instances of carnivores being able to endure great variations in temperature without being specifically modified. These three animals, therefore, can tell us nothing as to the Pleistocene climate.

#### *The Extinct Species.*

The extinct mammalia may be divided into three classes, which correspond with three out of the four into which the living Pleistocene species naturally fall. To the southern belong the two Maltese dwarf Elephants, as well as *Elephas antiquus* and *E. meridionalis*, *Rhinoceros etruscus*, *R. megarhinus*, *R. hemitechus*, and *Ursus arvernensis*, which passed from their head quarters, in the districts bordering on the Mediterranean, as far north as Norfolk. The Mammoth and Woolly Rhinoceros constitute the second or northern division. Found throughout Northern Asia together, even on the shores of the great Arctic Sea, they ranged through Russia and the whole European area south of the Baltic and north of the Alps. The Mammoth even ventured as far south in Europe as the valley of the Tiber, and in America as far down as the lower basin of the Mississippi. From its presence, in association with the southern forms,

mostly of Pliocene descent, in the Forest-bed and in Rome, as well as its more southern range, it must have been better adapted for living in a temperate or comparatively warm climate than the Woolly Rhinoceros.

The third group, which was probably fitted for a temperate climate, since it occurs neither in the north nor the south of Europe, consists of

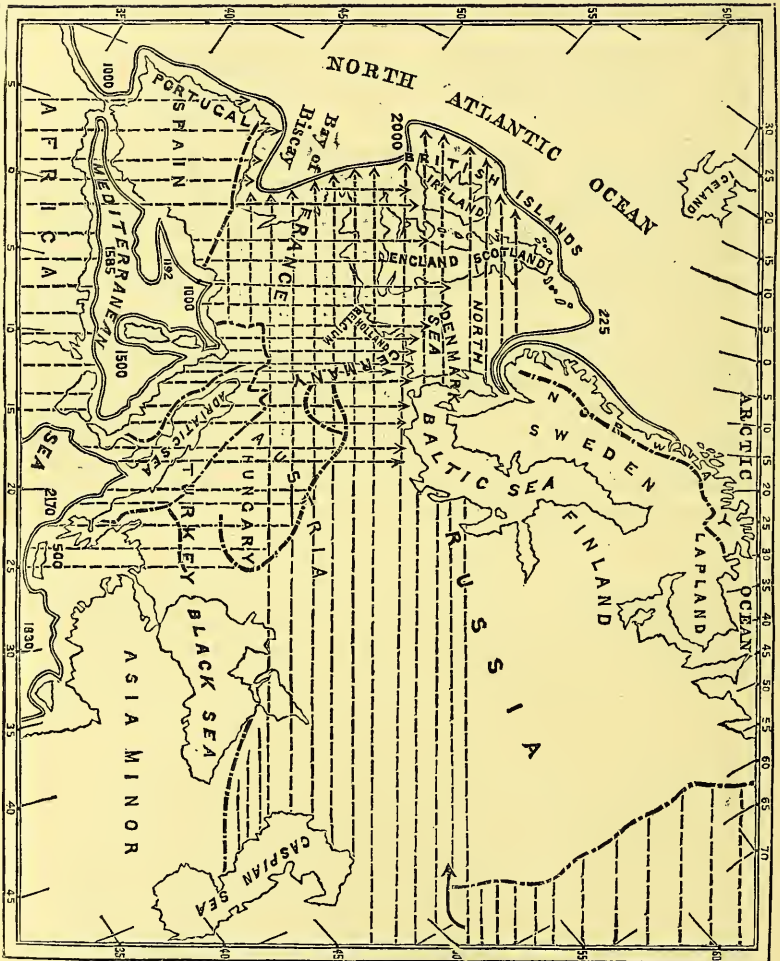
Trogotherium Cuvieri.	Cervus megaceros.
Machærodus latidens.	C. Browni.
Cervus carnutorum.	C. Sedgwickii.
C. verticornis.	C. Polignacæus.

The last species, like *Elephas meridionalis*, is a Pliocene animal which survived into the early Pleistocene stage, and has been discovered by MM. Croizet and Jobert in the lacustrine deposit of Mont Perrier, and identified by Dr. Falconer as occurring also in the Forest-bed. *Trogotherium Cuvieri* and *Cervus carnutorum* are found alike in the Forest-bed, and the deposit of St.-Prest at Chartres, while the *Machærodus latidens*, of Kent's Hole, is found as far south as Auvergne and a cave in the Jura. The Irish Elk ranges, in space, from Scania as far as the valley of the Po—and in time, from the Forest-bed era down to the prehistoric peat-bogs, being far more abundant in the Prehistoric than in the Pleistocene strata. It has not, however, been discovered in the latter further north than Quedlinburg, on the Continent, and Kirkdale cave, in Great Britain, although in the prehistoric deposits of Scania it is comparatively abundant (Nilsson, MSS.).

### 13. THE THREE CLIMATAL ZONES.

The inference as to the Pleistocene climate of Europe drawn from the range of the Pleistocene species which are still living is corroborated by an appeal to those which are now extinct; and, treating the whole mammalian land-fauna as one, we have three great climatal zones, marked out by the varying range of the animals—the northern (see Map, p. 436), into which the southern forms never penetrated, the southern, into which the northern species never passed, and an intermediate area in which the two found are mingled together. The latitude of Yorkshire is the extreme northern boundary which the southern forms never passed; and a line passing through the Alps and the Pyrenees is the limit of the range of the northern animals, properly so called. In the head quarters of the Reindeer and Musk-sheep in Scandinavia and Northern Russia, the climate must have been like that of those regions which they now inhabit; and in the head quarters of the *Rhinoceros etruscus*, *E. meridionalis* and *E. antiquus*, of the Spotted Hyæna, and the Hippopotamus it was most probably hot. In the following map the three zones are marked, the northern by horizontal, and the southern by vertical broken lines; while the intermediate area, in which the northern and southern animals were associated together, is represented by the crossing of the lines.

*Map of the Pleistocene Geography of Europe.*



The double line represents the probable outline of the Pleistocene land. The vertical broken lines show the range of the southern Mammoth, and the horizontal ones that of the northern forms.



## 14. THE PHYSICAL EVIDENCE AS TO CLIMATE.

The actual existence of two out of the three climatal zones during the Pleistocene age is amply proved by the physical evidence of the Pleistocene strata, and altogether irrespectively of the mammalia. The researches of many eminent observers prove that after the close of the Forest-bed era the temperature of Northern Europe gradually became lowered, until it became arctic in character, and the complex phenomena were manifested which we call glacial—the deposit of clays with large angular and scratched blocks, the grooving, polishing, and rounding of the tops of hills and of the bottoms of valleys, and the accumulation of marine gravels.

At the commencement of the Glacial period in Britain an enormous ice-sheet, similar to that under which Greenland now lies buried, extended from the hills of Scandinavia over North Germany, the North Sea, Scotland, Ireland, Cumbria, and the lower portion of England, as far south as the line of the Thames valley, leaving the grooved hill-tops and the Boulder-clay to show its extension\*. The land then most probably, as Mr. Godwin-Austen, Prof. Ramsay, and Sir Charles Lyell believe, stood higher than it does now. To this succeeded a period of depression, during which the mountains of Wales and the hills of Derbyshire and Yorkshire were submerged to a depth at least 1300 feet below their present level; and the waves of the sea washed out of the Boulder-clay the shingle and sand which constitute the “middle drift” of the north of England, Scotland, and Ireland†. Then the region north of the Thames valley was reelevated, and a period of glaciers set in, which, however, were of far less extent than those which preceded them, occupying isolated areas, and not uniting to form a continuous icy mantle to the country. There may have been, and probably were, many more changes in climate and geography than these three; but these are clearly and definitely marked in the whole of Britain north of the valley of the lower Thames, while the subdivisions are not so clearly traceable, and may be mere local phenomena‡.

From this it follows that there were at least three well-marked changes in the Pleistocene climate of Great Britain, if not of Northern France. The temperature of the Forest-bed era was lowered until it reached a minimum that found expression in the great continuous ice-sheet moving resistlessly down to the sea, over the lower hills and valleys, and traversing hills as high as 2500 feet§. 2ndly. Then, coincident with the marine depression, the climate became warmer, until certain southern mollusks, such as *Cardium rusticum*, found

\* Sir Charles Lyell has given an admirable summary of the glacial phenomena of Europe in ‘The Antiquity of Man.’

† For information regarding the Irish Drift I have to thank Mr. Kinahan, of the Geological Survey of Ireland. See also papers by Harkness and Hull, *Geol. Mag.* vols. vi. & viii.

‡ On this point see Mr. J. Geikie, *Geological Magazine*, No. 93, “On Changes of Climate in the Glacial Epoch.”

§ According to Jamieson, the top of Schehallion (Perthshire) is traversed by stria which pass over from a northerly direction. *Quart. Journ. Geol. Soc.* xxi. p. 162.

favourable conditions of existence in the seas which then covered Lancashire. 3rdly and lastly. On the land emerging from the sea, the isolated glacier-areas show that the climate was severe, but yet not so severe as in the time of the continuous ice-sheet. On the Continent the traces of this lowering of the temperature are to be found in the travelled blocks and the Boulder-clay, which occupy the whole region north of the continuation of the line passing through the Thames valley eastward into Russia. To the south, however, of this line there is no evidence of a continuous ice-sheet—a fact which can only be accounted for by the climate at the time having been less severe than in the northern region. Nevertheless a *mer de glace* extended far over the Jura from the lofty axis of the Alps; and glaciers have left their unmistakable moraines in the valley of the Rhine, at least as far down as Suabia, as well as in Lombardy. The Alps, indeed, formed an axis, from which the ice extended far down on every side into the lower districts. M. Desor has proved that the three climatal changes which are so marked are traceable also in Switzerland. The lignite beds of Dürnten, which have furnished the remains of *Elephas antiquus*, rest on an ancient moraine, and are also covered by a mass of glacial detritus. It is clear, therefore, that before the accumulation of the lignite the cold was sufficiently intense to allow of glaciers occupying the horizon, that during the growth of the trees on the spot the glaciers had retreated, and that subsequently there was a reversion to the intense cold of the first Glacial period. These three changes have not been traced in any other part of the Continent.

The moraines and *roches moutonnées* and detritus which cover the flanks of the Pyrenees prove that they formed an axis from which the glaciers radiated into France and Spain. And similar remains detected by M. Delanoue in the valley of the Dordogne prove that the higher region of Auvergne was also covered with ice.

The mere fact of these glaciated areas being isolated shows that the Pleistocene climate was less severe in Central than in Northern Europe, although the angular condition of the superficial detritus, pointed out by Mr. Godwin-Austen, in the south of England, and the twisted and contorted river-gravels of Britain and Northern France, noted by Mr. Prestwich, that have been disturbed by the contact of ice, imply a temperature considerably lower than that which is now found in those countries.

On physical grounds, therefore, we have reason to believe that in the Pleistocene period, treated as a whole, there were two distinct climatal zones—the arctic, which extended as far down as a line passing through the valley of the Thames eastwards, and a zone with cold winter and warm summer, which extended from this line as far south as the Alps and Pyrenees. In the one the northern division of the Pleistocene mammalia found their head quarters, while the other afforded a common feeding-ground for both northern and southern animals. And the northern boundary of the latter gradually passed northwards, as the temperature became warmer, as far as the shores of the Baltic, probably in the latest stage of the Pleistocene.

## 15. RELATION OF THE PLEISTOCENE MAMMALIA TO THE GLACIAL PERIOD.

The relation of the Pleistocene mammalia to the Glacial age, or the age of maximum cold, must now be considered. Did they invade Northern and Central Europe during the first or the second Glacial period, before or after the marine submergence indicated by the "middle drift"? We might expect, *à priori*, that as the temperature became lowered, the northern mammalia would gradually invade the region occupied before by the Pliocene forms; and such a mingling of Pleistocene and Pliocene animals we find in the pre-glacial forest-bed. Traces of such an occupation would necessarily be very rare, since they would be exposed to the grinding action both of the advancing glacial sheet, and, subsequently, to that of the waves on the littoral zone during the depression and reelevation of the land. At the time also that the greater part of Great Britain was buried under an ice-sheet they could not have occupied that region, although they may have been, and most probably were, living in the districts further to the south, which were not covered with ice. The labours, however, of Dr. Bryce and others have proved that one at least of the characteristic Pleistocene mammalia, the mammoth, as well as the reindeer, lived in Scotland before the deposit of the Lower Boulder-clay; while Mr. Jamieson has pointed out that these animals could not have occupied that area at the same time as the ice, and therefore must be referred to a still earlier date. Dr. Falconer has shown that the mammoth occurs in the Forest-bed; and his conclusion, which seemed to be doubtful, has been verified by fresh discoveries. The teeth and bones discovered in the ancient land-surface at Selsea also very probably indicate that the mammoth lived in Sussex before the glacial submergence, although they were never admitted by Dr. Falconer to be of the same age as the remains of *Elephas antiquus* from the same Preglacial horizon. On a careful reexamination of the whole evidence, I am compelled to believe with Mr. Godwin-Austen and Mr. Prestwich that the *à priori* argument that Pleistocene mammalia occupied Great Britain before the Glacial period is fully borne out by the few incontestable proofs that have been brought forward of the remains having been found in Preglacial deposits. And the scanty evidence on the point is just what might be expected from the rare accidents under which the bones in superficial deposits could have escaped the grinding of the ice-sheet, and the subsequent erosive action of the waves on the coast-line. The arrival of the northern and temperate Pleistocene mammalia in Britain in Preglacial times implies that they were living on the Continent before the low glacial temperature had set in. On the other hand the evidence is conclusive that they lived in Britain and on the Continent after the intense glacial cold had passed away, since their remains are found in deposits which rest on Boulder-clays. At Schussenried, for example, the reindeer, glutton, bear, and other animals were found by Prof. Fraas in a deposit which rested on the surface of the terminal moraine of the glacier of the



Rhine, which must therefore have retreated at the time the remains were accumulated by Palæolithic man. Prof. Carl Vogt's observation that the same fauna and flora occupied Europe before, during, and after the period of intense cold, seems to me to be amply proved by the discoveries at Dürnten, to which allusion has been made, and many others. The Glacial period can therefore no longer be viewed as a hard and fast barrier, separating one fauna from another, as Sir C. Lyell has shown; and the terms Preglacial, Glacial, and Post-glacial cannot be considered of any value in the classification of the mammalia. And although the earliest traces of man found in the river-deposits of Great Britain can be proved from their position to be of Post-boulder-clay age, the Brick-earth of Crayford excepted, it by no means follows that those which have been furnished by the caves of the south of England, or of the south of France, are also of the same age; and since the fauna amongst which he lived arrived here before the intense arctic severity of the glacial maximum had been reached in Britain, it is very probable that he came at the same time. In other words, if man be treated merely as a Pleistocene animal, there is every reason for the belief that he formed one of the North-Asiatic group, which was certainly in possession of Northern and Central Europe in Preglacial times. He occupied the area north of the Alps and Pyrenees with the animals of that group, and disappeared with them at the close of the Pleistocene period, and therefore may fairly be assumed to have arrived in Europe in their company.

#### 16. THE PLEISTOCENE INVADING FORMS.

If the Pleistocene mammalia be compared with those of the Pliocene strata of Auvergne, Montpellier, and the Val d'Arno, it will be seen that the following animals were not known in Europe before the Pleistocene age.

Man.	Panther.	Musk-sheep.
Musk-shrew.	<i>Felis caffer</i> ,	Ibex.
Pouched Marmot.	<i>Felis pardina</i> .	Chamois.
Alpine Marmot.	Serval.	<i>Antilope saiga</i> .
Hamster.	Cat.	Irish Elk.
Hare.	Spotted Hyæna.	Reindeer.
Alpine Hare.	Brown Bear.	<i>Cervus Browni</i> .
Rabbit.	Grizzly Bear.	Stag.
<i>Lepus diluvianus</i> .	Cave-bear.	Fallow Deer.
Lemming.	<i>Machærodus latidens</i> .	Roe.
Beaver.	Arctic Fox.	<i>Cervus verticornis</i> .
<i>Trogontherium Cuvieri</i> .	Mammoth.	<i>C. Sedgwickii</i> .
Lion.	Woolly Rhinoceros.	<i>C. carnutorum</i> .

The African Elephant and the Pentlands small Hippopotamus are added by the caves of Sicily, and the pigmy Elephants and the gigantic Dormouse by those of Malta.

#### 17. THE NORTH-WESTERN EXTENSION OF EUROPE.

The Pleistocene mammalia may be divided into three groups—those derived from Northern and Central Asia, those derived from Africa,



and those which were living in the same area in the Pliocene age. The migration of the first two groups into Europe at the close of the Pliocene age throws a very great light on the ancient geography. Had not the animals which lived in Europe during the Pliocene age been insulated by some physical barrier from those which invaded Europe from Asia, the latter would occur in our Pliocene strata as well as the former, and we might have had the mammoth and the mastodon associated here as well as in North America. Such a barrier is offered by the northern extension of the Caspian along the low-lying valley of the river Obi; and that the Caspian has extended further north than now in comparatively modern times has been proved by Dr. Pallas. It is therefore very probable that this was the barrier which divided the Pliocene mammalia of Europe from those animals which were living at the time in Asia, and which subsequently passed into Europe. The animals of Northern and Central Asia could not pass westwards before this barrier was removed by the elevation of the sea-bottom between the Caspian sea and the southern portion of the Urals. When this took place the Musk-shrew, Lemming, Brown and Grizzly Bears, Mammoth, Woolly Rhinoceros, Musk-sheep, Reindeer, Stag, and Roe passed over into Europe\*, those of them which were fitted for a temperate or moderately warm climate, such as the Stag, Roe, Brown and Grizzly Bears, passing down to the extreme southwest, while the rest did not go further to the south than the Alps and Pyrenees. Then there must have been a continuous mass of land extending from Northern Asia to the margin of the Atlantic, which has been proved by Mr. Godwin-Austen and others to have passed from Scandinavia to the west of the present coast-line of Ireland, of the south of England, and of France. [See Map, p. 436.]

#### 18. THE SOUTHERN EXTENSION OF EUROPE.

The same argument may be based on the African mammalia. The African Elephant could not have found its way northwards to Spain and Sicily, or the Serval to Spain, or the *Felis caffer* to Britain without an extension of the African mainland, so as to allow of the migration; and the same may be said perhaps of the Spotted Hyæna, although this animal, so widely spread through Central and Southern Europe, may have arrived by way of Asia Minor, as well as by a direct line, passing through Sicily and Gibraltar. Nevertheless, as Dr. Falconer has remarked, the area of the Mediterranean must have been very much smaller than it is now during the time that Malta, Sicily, and Candia were inhabited by the Pleistocene mammalia. The presence of *Hippopotamus Pentlandi* in these three islands proves that they were connected during the life-time of the animal; and this mass of land would afford a passage northwards to the African mammalia. The objection which is offered by the depth of

\* This is very nearly the same view as that held by Dr. Brandt, Imp. Acad. St. Petersburg, 'Zoogeographische und Paläontographische Beiträge,' April 4, 1867. See also Lartet, 'Comptes Rendus,' tome lxxi. p. 409.

the sea between Tunis and these islands, of over two hundred fathoms, does not at all invalidate the conclusion that there was actually such an extent of land, since that is a region in which at the present time land is being elevated and depressed irregularly by the exertion of those forces which find vent in Vesuvius and Etna. The great depth, however, of no less than 1400 fathoms, which intervenes between Candia and the mainland of Tripoli, offers a difficulty to the view that the land has been sunk to that depth since *Hippopotamus Pentlandi* lived in that island, and it cannot be quoted in favour of the continuity of land in that direction rather than towards Europe. The interval of a depth of sea of not more than 500 fathoms between it and Greece seems to me to imply that the island has been an appanage of Europe; and this conclusion is considerably strengthened by the recent discovery of *Hippopotamus Pentlandi* at Megalopolis, by Dr. Rolleston. I have therefore, in the Map, adopted the 500 fathom line as roughly indicating the ancient sea-margin.

The absence of the peculiar fauna of the caves of Malta in those of Sicily implies that the two areas were insulated from each other during the time that the pigmy Elephants and giant Dormouse were living in the former, and the African Elephant in the latter; for if this had not been the case the two faunas would have been likely to be mingled in regions which are now so nearly alike in climatal conditions. It is very possible that they may belong to two different stages of the Pleistocene; but this point cannot be decided until the Pleistocene faunas of Greece, Africa, and Asia Minor have been carefully compared and classified. The *Elephas antiquus* of Sicily points to a connexion by land with Italy, just as the *Elephas africanus* does to a connexion with Africa.

The striped Hyæna of the South of France and the Hippopotamus are Pliocene animals which survived into the Pleistocene age, and do not necessarily imply a direct continuity with Africa at the latter age; and the Lion and the Panther are as likely to have been derived from Asia as from Africa, since they now live on both those continents. The Chamois and the Ibex are most probably of North-Asiatic extraction, since they enjoy a climate that is not offered by the North-African continent. Of the rest of the animals it can only be said that they were unknown in Europe before the beginning of the Pleistocene age. In the Map (p. 436) I have represented the geography of the Mediterranean as implied by these animals, and corroborated in a striking degree by the evidence of the soundings. The barrier of land along which the African animals passed, on the one hand, into Spain, and on the other into Italy, is represented by portions of the sea-bottom which still stand far above the bottom of the Tyrrhenian and Ionian basins; and the depth is far less between the Morea and Candia than between the latter and Africa. The effect of a mass of land stretching, with but a slight break at the Mediterranean area, from the range of the Atlas to the extreme north of Europe, must necessarily have tended to produce extremes of climate similar to those which we now witness in masses

of land similarly situated, such as Northern Asia and North America. And these climatal extremes have been deduced, as we have already seen, from the analysis of the Mammalia.

### 19. THE PLIOCENE MAMMALIA.

The relation of the Pleistocene to the Pliocene fauna must now be examined; and this inquiry is of very great difficulty, because the latter has not yet been satisfactorily defined, although Prof. Gervais and Dr. Falconer have given the more important species of Auvergne, Montpellier, and the Val d'Arno. The following list is taken from Prof. Gervais's great work 'Zoologie et Paléontologie Françaises,' p. 349, the term Pseudo-pliocene merely implying that the fauna differs from that of the marine deposit of Montpellier, which he takes as his standard.

#### *Pseudo-pliocene of Issoire.*

Hystrix refossa.	Cervus ardens.	Canis borbonidus.
Castor issiodorensis.	C. cladocerus.	Felis pardinensis.
Arctomys antiqua.	C. issiodorensis.	F. arvernensis.
Arvicola robustus.	C. Perrieri.	F. brevisrostris.
Lepus Lacosti.	C. æstuariorum.	F. issiodorensis.
Mastodon arvernensis.	C. pardinensis.	Machærodus cultridens.
Tapirus arvernensis.	C. arvernensis.	Hyæna arvernensis.
Rhinoceros elatus?	C. causanus.	H. Perrieri.
Bos elatus.	Sus arvernensis.	Lutra Bravardi.
Cervus polycladus.	Ursus arvernensis.	

To these animals Dr. Falconer \* adds *Hippopotamus major*, *Elephas antiquus*, and *Rhinoceros megarhinus*, and he identifies *Rhinoceros elatus* with his new species *Rhinoceros etruscus*. Prof. Gaudry agrees with me in the belief that *Hyæna Perrieri* is identical with *H. striata* or the striped species.

Professor Gervais also identifies the *Equus robustus* of M. Pomel, from the same locality, with the common Horse, *Equus fossilis*.

The fauna of Montpellier is certainly very different from that of Issoire; but since it is neither Miocene nor Pleistocene, it must belong to one of the intermediate stages of the Pliocene. It includes

Semnopithecus monspessulanus.	Cervus Cuvieri.
Macacus prisceus.	C. australis.
Chalicomys sigmodus.	Sus provincialis.
Lagomys loxodus.	Hyænodon insignis.
Mastodon brevisrostris.	Hyæna — ?
Rhinoceros megarhinus.	Machærodus.
Tapirus minor.	Felis Christolii.
Antilope Cordieri.	Lutra affinis.
A. hastata.	

The *Mastodon brevisrostris* of this list is considered by Dr. Falconer to be identical with *M. arvernensis* of MM. Croiset and Jobert.

The fauna of the Val d'Arno differs from that of Montpellier and of Auvergne, and yet is considered by Dr. Falconer to be eminently

\* Palæont. Mem. vol. ii. p. 49.

typical of the European Pliocene \*. The animals identified by him in the museums of Italy are as follows :—

Felis.	Elephas meridionalis.
Hyæna.	Rhinoceros etruscus.
Machærodus cultridens.	R. megarhinus.
Mastodon arvernensis.	R. hemitæchus.
M. Borsoni.	Hippopotamus major.
Elephas antiquus.	

All these animals, with the exception of *Rhinoceros hemitæchus*, have been discovered in the Pseudo-pliocene of Issoire, while the Megarhine Rhinoceros and *Mastodon arvernensis* are the only two which have been obtained from the marine sands of Montpellier. The Pliocene animals, therefore, inhabiting Northern Italy are more closely allied to those of Auvergne than to those of Montpellier.

If these three localities be taken as typical of the Pliocene strata, we shall find that several of the species range as far north as Britain, and occur in deposits which, from the evidence of the mollusca, have been assigned to that age. *Mastodon arvernensis*, *Elephas meridionalis*, and *Ursus arvernensis*, have been obtained from the old land-surface which underlies the sand and shingle of the Norfolk Crag, in company with many forms of Deer and Antelopes which have not yet been identified, while the *Hipparion* is found in the marine crags of Suffolk.

The animals which especially characterize the Pliocene strata of Europe are *Machærodus cultridens*, *Mastodon arvernensis*, and *M. Borsoni*, besides the genus *Tapir*.

If this Pliocene fauna be compared with that of the Preglacial Forest-bed, it will be seen that the difference between them is very great. The Pliocene Mastodon Tapir, the majority of the Cervidæ, and the Antelopes are replaced by forms such as the Roe and the Red Deer, unknown up to that time. Nevertheless many of the Pliocene animals were able to hold their ground against the Pleistocene invaders, although, subsequently, as I have already shown, they disappeared one by one, being ultimately beaten in the struggle for existence by the new comers. The progress of this struggle has been used in the preceding pages as a means of classification.

## 20. CONCLUSION.

The following are the salient points of the Pleistocene age offered by the study of the land Mammalia in the area north of the Alps and Pyrenees.

### *The Pleistocene Period.*

#### A. The latest stage.

Palæolithic Man.	Stag, comparatively rare.
<i>R. tichorinus</i> , abundant.	Northern forms of life in full
<i>Elephas primigenius</i> , abundant.	possession of area north of
Reindeer, abundant.	Alps and Pyrenees.

\* Palæont. Mem. vol. ii. pp. 189, 190.



## B. The middle stage.

Palæolithic man.	<i>Rhinoceros megarhinus</i> , still
<i>Machærodus latidens</i> .	living.
Stag, abundant.	<i>R. tichorhinus</i> , present.
Northern forms of life present, but not in force.	

## C. The early stage.

The following animals are peculiar to this stage:—

<i>Trogontherium Cuvieri</i> .	<i>C. Sedgwickii</i> .
<i>Cervus verticornis</i> .	<i>C. carnutorum</i> .

The following make their appearance:—The Beaver, Musk-shrew, Cave-bear, Roe, Stag, Irish Elk, Urus and Bison, Wild Boar, Horse (?), Mammoth, Wolf, and Fox.

The Pliocene *Ursus arvernensis*, *Cervus Polignacus*, *Rhinoceros etruscus*, and *Elephas meridionalis* still living.

*The Pliocene.*

<i>Mastodon arvernensis</i> .	<i>Hipparion gracile</i> .
<i>M. Borsoni</i> .	No living species of Cervidæ.

The three subdivisions of the Pleistocene do not apply to the region south of the Alps and Pyrenees, because the northern group of animals did not pass into Spain and Italy. In these two latter countries we find that assemblage of animals living throughout the Pleistocene age, which in France and Britain lived only in the early stage.

## DISCUSSION.

Mr. PRESTWICH was hardly prepared to accept the proposed division of the Pleistocene mammalia into three groups—at all events so far as Britain was concerned. Neither could he draw that distinction between the beds at Erith and Grays and those higher up the Thames, which found favour with the author. The barrier offered by the river itself might to some extent account for the absence of Reindeer; and though there was a difference in the fauna in the two cases, it seemed hardly enough to mark any great distinction in time. As for the Hippopotamus, which occurred over the whole of Northern Europe, associated with the Musk-ox and large boulders, he could not see how the conclusion was to be escaped of its having been able to withstand greater cold than its present representative. Though the winters might have been colder, there was evidence in favour of the summers having been warmer; and the flora seems to have been much like that of the present day. The probable migrations of the different animal groups had already been pointed out by M. Lartet, though Mr. Dawkins had carried his investigation of the subject further. Mr. Prestwich called attention to the fact of the Mammoth having been found in Italy.

Mr. CHARLESWORTH regretted that the author had not included within his province any of the marine Crag-deposits, some of which had been regarded as Pleistocene. In these beds the fish had been regarded by M. Agassiz as tropical in character, while M. Deshayes considered the molluscan remains arctic. A similar discrepancy had been observed in other deposits of the same series; and he con-

sidered, therefore, that it was unsafe to generalize from any one series of remains, as, unless the whole fauna was taken into consideration, it was probable that erroneous conclusions would be arrived at.

Mr. FLOWER considered that both on geological and palæontological grounds the ossiferous caves and the river-deposits were separable, and ought to be separated, and that no satisfactory results would be obtained by placing in the same category the Mammalian remains of a hundred and fifty rivers and a great number of caves of widely different ages and characters.

Mr. EVANS observed that in generalizations of this kind not only the whole of the palæontological evidence should be taken into account, but the stratigraphical also. With regard to the author's middle division of the mammalia, he thought that eventually this would have to be modified. If it were to be maintained there would be a great difficulty in accounting for the presence of the high beds at Shacklewell and Highbury, as these, though in a valley confessedly excavated by the river, and regarded as of more recent age than the lower beds, would yet be at a far higher level. Though accepting the probable existence of man in preglacial times, he pointed out that up to the present time the beds in Britain in which his works had been found were all postglacial.

Mr. BOYD DAWKINS, in reply, stated that, in forming his conclusions, he had not left out of view the evidence afforded by the classes of remains other than those of mammalia; but they threw no light on the classification. With regard to the middle of his divisions of the Pleistocene mammalia, he relied to a great extent on the presence of *Rhinoceros megarhinus*, and of a large number of Stags, to say nothing of the absence of the Reindeer. He did not attach so much importance to the question of the level, as in some cases (for example the Forest-bed of Norfolk) it was not a test of age. He gave his reasons for not regarding the Mammoth as an exclusively arctic animal. His remarks with regard to M. Lartet's classification referred rather to the expanded views of his followers than to those of M. Lartet himself. He acknowledged his obligations to MM. Gaudry, Fraas, Rütimeyer, and Nilsson for various facts which they had been kind enough to communicate to him.

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JUNE 19, 1872.

Richard Anderson, Esq., F.C.S., Uddingstone, near Glasgow; Lieut. Henry Allen Gun, R.E., South Kensington; Sir Victor Brooke, Bart., Colebrooke, Lisnaskea, Fermanagh, Ireland; Edmund James Smith, Esq., 16 Whitehall Place, S.W., and Peter Pickup, Esq., Townley, Burnley, Lancashire, were elected Fellows of the Society.

The following communications were read:—