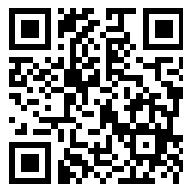

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AUTHOR'S EDITION

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY.
F. V. HAYDEN, U. S. Geologist-in-Charge.

I.—The Relations of the
HORIZONS OF EXTINCT VERTEBRATA
OF
EUROPE AND NORTH AMERICA.

II.—Observations on the
FAUNÆ
OF THE
MIOCENE TERTIARIES OF OREGON.

BY
E. D. COPE.

EXTRACTED FROM THE BULLETIN OF THE SURVEY, Vol. V, No. 1.

WASHINGTON, February 28, 1879.

Art. II.—The Relations of the Horizons of Extinct Vertebrata of Europe and North America.

By E. D. Cope.

The history of the succession of life upon any one portion of the earth's surface is replete with matter for speculation. It shows us a series of faunæ succeeding each other, each of which, in many instances, commences without previous announcement in the forms of older periods, and disappears without leaving representatives in later ones. With this basis of fact, which naturally enough has been furnished by the longest explored and best known portion of the earth, Europe, we turn to other lands with the hope of obtaining further light upon a subject so full of mystery. These types of life, did they originate in a single centre, from which they disseminated themselves? and, if so, did each form originate in a region of its own or not? Or, did the same types of generic structure appear at different points on the earth's surface independently; and, if so, whether coterminously, or at different times?

For a solution of these and similar questions, we naturally look to a comparison of the facts first established, with those obtained more recently by exploration in other regions. In this quest, no portion of the earth offers greater promise of results than America. As the second great continent, separated from the other by the greatest possible water surface, we anticipate the widest diversity in the character of its life-history. If the types of life have originated independently, we will find evidence of it by studying American palæontology; if their origin has been through gradual modification, America should furnish us with many intermediate faunæ.

The identification of the generic types of North American *Vertebrata* has now advanced to a point which renders such a comparison possible. Although the subject is in its infancy, the following pages will show that an important contribution to it can be now made. The comparisons instituted in this paper commence with the coal-measures, and with the *Batrachia* of that period. As regards the palæozoic fishes, I have not yet devoted that attention to them which is necessary for their discussion, and I refer to the papers of Newberry for several important identifications of genera as common to the two continents.

The structure of the *Batrachia* of the coal-measures is not yet sufficiently well known to enable the most exact comparisons to be made, but close parallels, if not identities, of genera exist. Such are the

Oëstocephalus and *Ceraterpeton* of Ohio as compared with the *Urocordylus* and *Ceraterpeton* of Great Britain.

The Permian vertebrate fauna which I discovered in Illinois and Texas, exhibits close parallels, but not yet generic identity, in the two continents. Thus, the American *Clepsydrops* and *Dimetrodon* are near to the *Deuterosaurus* of Perm in Russia, and the *Lycosaurus* of the mountains of South Africa. The Texan genus *Pariotichus* may, with further information, prove to be identical with *Procolophon* Ow. from the Tafelberg. Humeri of the type discovered by Kutorga in Russia, and by Owen in South Africa, are found in North America, and the same remarkable type has been recently discovered by Gaudry in France. The peculiar type of Labyrinthodont vertebræ described by me under the genus *Rhachitomus* from Texas has been discovered by Gaudry in France. The present indications are that close similarity between the faunæ of this period in Europe and America will be discovered. Nevertheless, up to the present time no representatives of the striking American forms *Diadectes*, *Bolosaurus*, *Empedocles*, and *Cricotus* have yet been found in any other continent.

As regards the Triassic fauna, it differs from that of the Permian in being better known in Europe than America. As marine Trias is little developed in North America, so the vertebrate fauna of the Muschelkalk has not been discovered in the latter country. It is otherwise with the Keuper. The characteristic genus of that epoch, *Belodon*, existed in America, and parallels, if not identity, exist in the genera *Thecodontosaurus* and *Palæosaurus*. These are known in America from teeth only. The reptiles are accompanied in North America, as in Europe, by *Stegcephalous* *Batrachia*, mostly Labyrinthodonts, but their generic affinities are yet unknown.

The great Jurassic faunæ are as yet but sparsely represented in North American palæontology. The marine *Vertebrata* of the Lias are either unknown or are represented by a few provisional identifications of unsatisfactory fragments. We do not yet know any deposits in North America which contain the typical reptilian genera *Plesiosaurus*, *Ichthyosaurus*, *Pliosaurus*, and *Dimorphodon*, or the fishes of the *Dapediidae*. This formation, so important in Europe, is almost omitted from the North American series. A few more characteristic fossils of the Rocky Mountain region represent the Oölite, particularly the Upper Oölite, while *Teleosaurus* and *Steneosaurus*, and their allies, are not yet known from North American beds. Strata said to be included in the Dakota (which on the evidence of plants and invertebrate fossils has been placed at the bottom of the Cretaceous series) have produced a genus not yet distinguishable from *Megalosaurus*. This genus has not been identified beyond doubt from above the Oölite in England. From the same beds in the Rocky Mountain region come genera which nearly resemble the one from the English Oölite (Forest Marble) called by Phillips, *Cetiosaurus*, and the genus from the Oxfordian of Honfleur, called by von Meyer,

Streptospondylus. Beyond this no comparisons can be made, and we therefore pass to the rich fauna of the Kimmeridge. North America cannot show such records of this epoch as have been found in Europe. There are no *Archæopteryx*, *Rhamphorhynchus*, nor *Pterodactylus*; no *Lepidolepis*, *Thriassops*, nor other of the numerous fishes of Solenhofen. The *Omosaurus* has, however, some very close relatives in the supposed Dakota beds of the Rocky Mountains. No remains of that primitive Marsupial fauna which occurs in the Purbeck have yet been detected in the Western Continent. A partial representation of the Wealden fauna of Europe is found in the beds of the Rocky Mountains mingled with the types of the Oölite and Kimmeridge already mentioned. The relationships of this fauna to those of the European Jurassic series may be thus exhibited:

American.	European.
CAMARASAURUS BEDS.	WEALDEN.
?	<i>Iguanodon</i> .
? <i>Hypsilophodon</i> .	<i>Hypsilophodon</i> .
? <i>Cetiosaurus</i> .	<i>Hylæosaurus</i> .
<i>Camarasaurus</i> .	<i>Cetiosaurus</i> .
<i>Amphicælias</i> .	<i>Eucamerotus</i> .*
? <i>Goniopholis</i> .	<i>Ornithopsis</i> .
<i>Hypsirhophus</i> .	<i>Goniopholis</i> .
<i>Caulodon</i> .	KIMMERIDGE.
<i>Epanterias</i> .	<i>Omosaurus</i> .
? <i>Megalosaurus</i> .	? <i>Caulodon</i> .†
	OXFORD.
	<i>Streptospondylus</i> .
	OÖLITE
	" <i>Cetiosaurus</i> ."
	<i>Megalosaurus</i> .

From the above table it will be seen how difficult it is at the present to parallelize the related beds of the Jurassic periods of the two continents at the present time. All that can be said is that many types resembling † nearly those of different horizons of the European Jurassic are found to have lived together or near together in the Rocky Mountain region of North America.

That the Cretaceous fauna of North America was the richest in the cold-blooded *Vertebrata* is indicated by the present state of discovery. The ocean of the interior of the continent deepened from the beginning

* *Chondrosteosaurus* Owen.

† *Iguanodon præcursor* Sauv.

‡ A near affinity has been shown by Professor Owen to exist between *Eucamerotus* and *Camarasaurus*. Professor Owen believes these genera to be identical; but the neural spines of the anterior dorsal vertebræ are very different, being single in the former, and double in the latter.

of the period until the epoch of the Niobrara, and then gradually shallowed until the elevations of the bottom began to divide the waters. The closing scenes of this great period were enacted amid a labyrinth of lagoons and lakes of brackish and fresh water, whose deposits form the beds of the Laramie epoch.

The fauna of the deep-sea epoch, the Niobrara, is the best known. Here the remains of *Pythonomorpha* constitute its prevailing characteristic, while *Elasmosaurus* and *Polycotylus*, with but few species, represent the numerous *Sauropterygia* of Europe. Crocodiles were apparently wanting, while turtles and a peculiar group of *Pterosauria* were only moderately abundant. The fish fauna was very rich and varied. Here the *Saurodontidæ*, like the Molluscous family of the *Rudistes*, appeared, and as soon disappeared, accompanied by the peculiar form, *Erisichthe*, and the family of *Stratodontidæ*. The genera of Mount Lebanon, *Leptotrachelus* and *Spaniodon*, occur in this bed in Dakota; but the closest parallelism is exhibited with the Lower Chalk or Turonian of Western Europe. The general *facies* of the reptilian fauna is that of the Lower Chalk, and there is little doubt that several genera are identical in the two continents, e. g. *Elasmosaurus*. The apparent peculiarity of the Chalk in America is the abundance of forms (four genera) of *Pythonomorpha* with numerous species, while but two genera have yet been found in Europe, and the presence of birds, with *biconcave* vertebræ, and teeth. This interesting type, which was first discovered by Seeley in the genus named by him *Enaliornis*, and afterwards found by Marsh to possess teeth, has been found at a lower horizon in England, the Upper Greensand. But in England, France, and Westphalia occur the genera of fishes above mentioned, as *Portheus*, *Ichthyodectes*, *Saurodon*, *Saurocephalus*, *Erisichthe*, *Empo*, *Pachyrhizodus*, *Enchodus*, *Leptotrachelus*, etc. This close relationship of the horizons permits an identification, and it is the first instance which appears to me to be susceptible of satisfactory demonstration.

The next horizon of the Cretaceous which has yielded many vertebrate remains in North America is the Fox Hills formation (including the Fort Pierre bed). Here the genus *Mosasaurus* appears in America, and is accompanied by the earliest crocodiles with procœlous vertebræ, and by numerous marine turtles which partake of the characters of both *Chelydridæ* and *Cheloniidæ*, which I have called the *Propleuridæ*. *Beryx* appears first here in America. The predominant genus of fishes is *Enchodus*, and the principal *Dinosauria* are *Laelaps* and *Hadrosaurus*. This horizon has been parallelized with the Maestricht of Europe, and several genera are common to the two beds; such are *Mosasaurus* and *Enchodus*. The genus *Hadrosaurus*, and the family of turtles I have called the *Adocidæ*, remain undiscovered in Europe; hence the identity of faunæ cannot be established.

The lacustrine beds, or summit of the American Cretaceous series, the Laramie of Hayden, present the remains of a populous fauna and a rich

flora. The students of the palæobotany have declared this flora to be of Eocene, and the later portions of Miocene character, while the lacustrine constitution of the strata has influenced the stratigraphic geologists to concur in the view that the formation should be arranged with the Tertiary epochs. That the fauna was of a mixed character is the result of a study of its vertebrate fossils. The predominant type in North America was the *Dinosauria*, which were abundant in species and individuals, and this fact alone will suffice most palæontologists as a reason for referring the epoch to the Cretaceous series. The genera of *Dinosauria* (*Palæoscincus*, *Cionodon*, *Diclonius*, *Monoclonius*, *Dysganus*, etc.) have not yet been found in any other part of the world. Mingled with them were species of crocodiles and turtles of indifferent character, while a number of other forms existed which had a limited range in time, and hence are important indicators of stratigraphic position. Such are the genera of fishes, *Myledaphus* Cope and *Clastes* Cope, which have been found also near Reims, France, by Dr. Lemoine, in the Sables de Bracheux, which are regarded as the lowest Tertiary. Such is the curious Saurian type *Champsosaurus* (Cope) (*Simædosaurus* Gerv.), and the turtle genus *Compsemys* Leidy, which Lemoine finds a little higher up in the series, in the Conglomerate of Cerny, which is in the lower part of the Suessonian. In France, a genus of the Laramie, *Polythorax*, extends into the Lignite or upper *Coryphodon* bed of the Suessonian. Thus the Laramie is intercalated by its characters between the Cretaceous period on the one hand and the Tertiary on the other, and its fauna includes genera and orders of both great series. These relations may be exhibited in tabular form as follows. I here include the faunæ of the Sables de Bracheux and of the Conglomerate of Cerny as one, since both possess the types of the Laramie, while the horizon of the Lignite of Meudon, or the Suessonian, does not.

SABLES DE BRACHEUX AND CON-
GLOMERATE DE CERNY.

LARAMIE.

a. TERTIARY.

Lophiochærus.
Plesiodapis.
Pleuraspidotherium.
Arctocyon.
Clastes.

Clastes.

β. PECULIAR.

Champsosaurus.
Compsemys.
Myledaphus.

Champsosaurus.
Compsemys.
Myledaphus.
Scapherpeton.

SABLES DE BRACHEUX AND CON-
GLOMERATE DE CERNY.

LARAMIE.

γ. CRETACEOUS.

*Palæoscincus.**Dysganus.**Monoclonius.**Diclonius.**Cionodon.**Lælaps.**Aublysodon.*

If the Conglomerate of Cerny is the same horizon as the Conglomerate of Meudon, we must add *Coryphodon* to the upper left-hand column, and probably *Gastornis* also. The result is clear that the French and American formations together bridge most completely the interval between the Cretaceous and Tertiary series, as has been anticipated by Hayden, in America, on geological grounds. It is also evident that another formation must be added to the series already recognized in France, viz, the Laramie or Post-Cretaceous. This will be defined as the beds of the genera *Champsosaurus* and *Myledaphus*. In France, the presence of mammalia will characterize the formation as a subdivision, for which it is probable that the name Thanetian must be retained; while to the American division, which is characterized by the presence of *Dinosauria*, the name of Laramie beds has been given.

The Eocene fauna is so varied, especially in Europe, that it is necessary to compare the divisions separately, as in the case of the Cretaceous. Thus, the fauna of the Suessonian is quite as distinct from that of the Calcaire Grossier and Gypse (Parisian and Tongrian) in France as are those of the Wasatch and Bridger epochs in North America.

I have already identified the Wasatch with the Suessonian or Orthocene, on account of the community of the following genera in the two continents: *Coryphodon*, *Hyracotherium*, *Amblyctonus*, *Clastes*, and a form of birds close to *Gastornis*. I can now add *Phenacodus*, *Orotherium* (Cope), and very probably *Hyopsodus*, *Adapis*, *Opisthotomus*, and *Prototomus*. But, as above mentioned, in the lower beds of the Suessonian in France occur genera which are, so far as yet known, wanting in the Wasatch of America, but present in the beds of the Laramie. Such are two genera in the Conglomerate of Cerny, and four genera in the lower Sables de Bracheux. In the former bed, they are associated with the mammalian genera *Lophiochærus*, *Plesiodapis*, *Pleuraspidotherrium*, and *Arctocyon*; and in the lowest, with a form referred with doubt to *Hyracotherium*. Thus the generalization may be made that the characteristic genera of reptiles and fishes of the Laramie of North America are in America associated with Cretaceous *Dinosauria*, and not with *Mammalia*; while in Europe they are associated with *Mammalia*, and not with *Dinosauria*. In arranging the Laramie Group, its necessary position is

between Tertiary and Cretaceous, but on the Cretaceous side of the boundary, if we retain those grand divisions, which it appears to me to be desirable to do. The reasons for retaining it in the Cretaceous are two, viz: (1) because *Dinosauria* are a Mesozoic type, not known elsewhere from the Tertiary; (2) because *Mammalia* (should they be found in the future in the Fort Union) are not equal as evidence of Tertiary age, since they have been also found in Jurassic and Triassic beds. The parallelism of the American Wasatch with the Upper Suessonian of France is the second identification which may be regarded as provisionally established. The only discordant elements at present known are the *Tæniodonta* of the Wasatch, which have not been so far found in Europe, and the genus *Lophiodon*, which is unknown in America.

Above the Suessonian, a divergence in the characters of the European and North American faunæ commences, and continues to be marked throughout the remainder of Tertiary time. So far as the *Mammalia* are concerned, the diversity between the continents was greater during the periods of the Upper Eocene and Miocene than at the present era. During these periods, a limited number of genera, common to the two continents, was associated with numerous genera in the one which did not exist in the other. As a consequence, our palæontological means of identification of the horizons are limited to a restricted list, and the task of applying a uniform nomenclature is, under the circumstances, difficult. Another difficulty in the way of determining the place of the American beds in the European scale consists in the fact that the physical history of the two continents during the Tertiary period appears to have been different. In America, the changes of level appear to have been more uniform in character over large areas. Each deposit has a wider geographical extent, and the fauna presents less irregular variation. In Europe we have a great number of comparatively restricted deposits, each of which differs from the others in possessing more or less peculiarity of fauna. After a study of these faunæ, their natural arrangement in Europe into three series, Eocene, Miocene, and Pliocene, does not appear to rest on any solid basis. This is especially true of the distinction between the first two; and authors are at variance as to the point of demarkation between the last two. Thus, the Tongrian is the summit of the Eocene according to Renevier, while Gaudry, with Filhol and others, places it at the base of the Miocene. One opinion is as well supported by facts, as now interpreted, as the other.

Let us now consider the nature of the evidence on which we should rely in classifying faunæ and the deposits which contain them. We are accustomed, at present, to rely for our definitions upon all the faunal peculiarities upon which we can seize: the period of appearance of certain types; the duration of certain types; and the disappearance of certain types, depending on orders, families, and genera for the major divisions, and species at a given locality for the lesser. It is, of course, evident

that either of the above-mentioned three criteria are variable quantities, since discovery is constantly extending our knowledge of the distribution of types. Hence the definitions are empirical and temporary. We must then, if we desire a stable system, examine the principles involved, and endeavor to discover definitions which stand on stronger foundations than those which we now possess.

As a matter of fact, the old definitions of epochs and periods are continually invalidated by new discoveries. As a matter of theory, this should be the case.

To the believers in the doctrine of derivation, the obliteration of faunal distinctions is not a cause of surprise. Such await with confidence the day when complete phylogenies will be possible, and at present regard the interruptions in the succession of life as local only. Will the result then be, that palæontology will cease to be available in the definition of ages and of deposits? I answer no, on various grounds. Interruptions in the succession of life in any given locality due to various causes have doubtless often occurred, and have left traces in the crust of the earth which are ineffaceable by discovery. But apart from this, one fact in this history is patent both to the friends and to the opponents of the doctrine of derivation. It is known that the world has witnessed, at every stage of its history, the extinction of some important type of life. Familiar examples are the *Placodermi* of palæozoic time, the various reptilian groups of Mesozoic time, and the *Amblypoda* of the Tertiary. Each minor subdivision of time offers its own record of persistences and extinctions of particular families and genera.

Now, all departments of biology compel us to recognize the law of classification, that the order of forms is from the less to the more generalized, from the simple to the more complex, and *vice versa*, whether the lines of succession be those of descent or of creative order; and this law is true in time as well as in classification. It follows from this, that all types of life are, at the time of their appearance, less distinct and more general in their characters than they are later in their history.

It also follows, as a consequence of the principle of descent, which states that the types of one age have taken their origin from generalized types of preceding ages, that there is no descent from the most specialized types; which is to say, conversely, that the genera, families, and orders whose extinction has been a marked feature of every geologic age have been the specialized types of those ages.

We now have a clue to a basis of a definition for fauna, and hence for epochs, which discovery can safely build upon. The successive increments of structure by which an important modification of animal type is introduced preclude the possibility of exact determination of the time at which such type may be said to have *appeared*. Even where such a point may be arbitrarily fixed, the type must then be less char-

acteristically represented than it is at the other limit of its existence, viz, the period of its disappearance.

For these reasons I must regard the latter criterion as the true one in the discrimination of the subdivisions of geologic time, while the point of the appearance of types must be looked upon as of provisional use only, and this quite independently of the changes which discovery will from time to time compel us to make in our knowledge of the distribution of life in time and space. It must, however, be borne in mind that disappearance may be due to two causes: first, to extinction; and, secondly, to modification; a distinction which is entirely essential. The case of disappearance by modification is identical with that of appearance by modification, and cannot be used otherwise in classification. It is then the period of extinction of types to which I have reference.

With these principles in view, we continue the comparison of the extinct faunæ of Europe and North America. If we take a general view of the Tertiary faunæ, we find that the following well marked types representing families and higher groups have become extinct, and have left no living descendants or successors: Among *Insectivora*, the *Leptictidæ* in North America; also the American Bunotherian groups *Taniodonta* and *Tillodontæ*; also the *Mesodontæ* of both continents; of *Edentata*, *Macrotherium* and *Ancylotherium* in Europe, and the *Megatheriidæ* in North America; among the *Carnivora*, the *Hyænodons* and *Proviverræ*, with the *Machærodi*; of *Ungulata*, the entire order of *Amblypoda*, which, however, doubtless disappeared in some of its members by modification; but its only known suborders, the *Pantodontæ* and the *Dinocerata*, became absolutely extinct. Among *Perissodactyla*, both continents lost by extinction the *Chalicotheriidæ*, which terminated in a great development in North America; the genera *Hippotherium** and *Stylonus* of the line of the horses, and the *Rhinoceriidæ*. Of *Artiodactyla*, two great divisions, representative of each other in the two continents, totally disappeared, viz, the *Oreodontidæ* and the *Anoplotheriidæ*; to which must be added the *Hypotamidæ*. Of true ruminants, the most important type which has disappeared from both continents is that of the *Camelidæ*. Of Suilline genera, *Anthracotherium* and *Elotherium* may be looked upon as having left no persistent successors. Last of all, the *Proboscidea* retreated to the continents of the south.

In view of the complexity of the European record, I first present the relations of the above mentioned phenomena as displayed in the simpler American system. As the present essay commences with the earliest periods, I exhibit the succession in descending order on the page. The horizons of the Tertiary which present distinct terrestrial faunæ in North America have been named the Wasatch, the Bridger, the Uinta, the White River, the Loup Fork, the *Equus* beds, and the Champlain.

* *Equus* came through *Protohippus*, the cotemporary of *Hippotherium*.

The types which became extinct* with the close of each of these epochs are the following :

WASATCH.	LOUP FORK.
<i>Gastornithidæ</i>	<i>Rhinoceriðæ.</i>
<i>Pantodonta.</i>	<i>Hippotherium.</i>
BRIDGER.	<i>Stylonus.</i>
<i>Bænidæ.</i>	<i>Oreodontidæ.</i>
<i>Tillodonta.</i>	EQUUS BEDS.
<i>Mesodonta.</i>	<i>Megatheriidæ.</i>
<i>Proviverra.</i>	<i>Machærodus.</i>
<i>Dinocerata.</i>	<i>Tapiridæ.</i>
WHITE RIVER.	<i>Elephas.</i>
<i>Leptictidæ.</i>	<i>Camelidæ.</i>
<i>Hyænodon.</i>	
<i>Chalicotheriidæ.</i>	
<i>Hyopotamidæ.</i>	

The above table exhibits the present state of our knowledge : it will doubtless be much extended by future discovery, but not otherwise modified.

The numerous able writers on European vertebrate palæontology have more frequently recorded the appearance of types in defining their faunal divisions than their disappearance. The following table is compiled from the writings of Gervais, Gaudry, Pomel, Filhol, Renevier, and others, but is not as complete as I would desire.

SUESSONIAN.	FALUNIAN.
<i>Pantodonta.</i>	<i>Anchitherium.</i>
PARISIAN (Bruxellian, Bartonian, and Sestian).	<i>Anthracotherium.</i>
<i>Palæophis</i> (Bruxellian).	<i>Palæochærus.</i>
<i>Proviverra.</i>	<i>Cænotherium.</i>
<i>Pterodon.</i>	OENINGIAN.
<i>Mesodonta.</i>	<i>Ancylotherium.</i>
<i>Lophiodon</i> (Bruxellian).	<i>Dinotherium.</i>
TONGRIAN.	<i>Hippotherium.</i>
<i>Palæotheriidæ.</i>	<i>Aceratherium.</i>
<i>Chalicotherium.</i>	SUBAPENNINE.
<i>Anoplotheridæ.</i>	<i>Mastodon.</i>
<i>Elotherium.</i>	<i>Tapiridæ.</i>
AQUITANIAN.	DILUVIAL.
<i>Hyænodon.</i>	<i>Hyæna.</i>
<i>Hyopotamus.</i>	<i>Machærodus.</i>
	<i>Elephas.</i>
	<i>Rhinocerus.</i>
	<i>Hypopotamus.</i>

* This means, as already mentioned, the forms which left no direct successors in the Nearctic and Palæarctic Faunæ.

The above tables show that the history of mammalian life in the two continents presents many points of resemblance; but that there is a great difficulty in correlating the epochs represented by the known faunæ. As regards the two primary divisions, Eocene and Miocene, they have no special *raison d'être*, as such faunæ as the Tongrian and Oenigian are absolutely transitional in their character. More detailed comparisons of the European and American faunæ bring out many relationships not displayed by the above tables, and which I will now briefly consider.

In the American Bridger, various genera of *Mesodonta* represent the few *Adapidæ* of the Parisian, the genus *Adapis** Cuv. being probably common to the two continents. The American *Anaptomorphus*, a true Lemur, has been found by M. Filhol in the Phosphorites, and named *Necrolemur*. The characters of the numerous *Carnivora* of the Bridger are as yet unknown. The *Stypolophus* of the Bridger is perhaps the *Prototomus* of the Wasatch, and this again has been discovered by M. Filhol† in France; while a very similar, if not the same, genus has been discovered in the Swiss Siderolitic, and named *Proviverra*. *Hycenodontidæ* probably occur in the Bridger. Nowhere in Europe do we find the *Dinocerata* and *Tillodonta* of the Bridger. *Palæosyops* is also unknown in Europe, but it plays the part in America of the *Palæotherium*, from which it does not greatly differ in structure. The latter genus is most largely developed in the Parisian, but is also characteristic of the Tongrian. *Hyrachyus* is the American *Lophiodon*, the difference between them being but slight: both are found in France; the former in the Lower Parisian, the latter in the Phosphorites. *Tapirus*‡ Gerv. is a genus common to the Bridger and to more than one horizon of the Parisian. The squirrel-like rodents of the Bridger are like those of the Parisian, but they are not confined to either epoch. The character which distinguishes the Parisian most widely from the Bridger, besides the absence of the *Dinocerata* and *Tillodonta*, is the presence of numerous Selenodont *Artiodactyla*, as *Xiphodon*, *Cænotherium*, *Amphimeryx*, *Anoplotherium*, etc. These are of primitive type, it is true; the *Anoplotheriidæ* especially having probably four toes in the very short manus (*Eurytherium*), including the pollex, and three behind. They also display the character of a fifth crescent of the superior molars, which is wanting in the higher Selenodont types. But even these genera are absent from the Bridger. The *ensemble* is then, that the latter displays relationships backwards, or to the Suessonian, while the Parisian has a later *facies*, constituting an approach to the Tongrian and White River.§

The following table presents the relations of the Bridger fauna succinctly, but it is much less complete than we hope to make it when its

* *Notharctus* is undistinguishable from *Adapis* in inferior dental characters.

† It is described as *Cynohyænodon* with two species.

‡ Gervais, 1850; *Heleletes* Marsh, 1872.

§ See Ann. Rept. U. S. Geol. Surv. Terrs. 1873, pp. 461-2, where this view is proposed.

numerous species now represented by catalogues of names are fully described. The Parisian is here regarded as including the divisions Bruxellian, Bartonian, and Sestian (Gypse).

PARISIAN.

Didelphys.
Vespertilionidæ.
Plesiarctomys.

Hyænodontidæ.
Adapis.
Anaptomorphus (Phosph.).

Palæotherium.
Lophiodon.
Hyrachyus (Phosph.).
Tapirulus.
Anthracotherium.
Chæropotamus.
Dichobune.
Anoplotherium.
Xiphodon.
Amphimeryx.

BRIDGER.

? *Didelphys.*
Vespertilionidæ
Plesiarctomys.
Tillodonta.
Hyænodontidæ.
Adapis.
Anaptomorphus.
Dinocerata.
Palæosyops.

Hyrachyus.
Tapirulus.
Achænodon.

The rich Tongrian (Stampian) fauna is, according to authors, represented in the Sables de Fontainebleau, Puy en Velay, Ronzon, Hempstead, and Cadibona in Italy. We find here *Didelphys* in abundance, *Hyænodon*, *Amphicyon*, *Cynodon*, *Palæotherium*, *Paloplotherium*, *Chalicotherium*, and *Aceratherium*. Of *Artiodactyla*, the Suillines are *Anthracotherium* and *Elotherium*; the Selenodonts, *Hyopotamus* and *Gelocus*. This list is the nearest known counterpart of that of the fauna of the White River epoch of North America. To reproduce the latter, we must omit from the above catalogue the genera of *Palæotheriidæ*, and replace them by the allied Chalicotheroid *Menodus* and *Symborodon*, subtract *Anthracotherium*, and add the great body of the *Oreodontidæ*. Then there are included in the White River fauna the higher Selenodont Artiodactyles of the *Poëbrotheriidæ* and *Hypertragulidæ*, the corresponding types of which belong to the fauna of St. Gerand le Puy in France, or the Aquitanian epoch, which directly succeeded the Stampian. In Europe we have here *Dremotherium*, *Amphitragulus*, *Lophiomeryx*, *Dorcatherium*; in America, *Leptomeryx*, *Hypertragulus*, *Hypisodus*, and *Poëbrotherium*. It is curious that while *Leptomeryx* is also European,* it has not yet been found above the Phosphorites. Among Suillines, the *Palæochærus*† of the Oregon White River beds has also not been found

* I think M. Filhol's *Prodremotherium* is identical with *Leptomeryx*.

† *Thinohyus* Marsh appears to be the same.

below the Aquitanian in Europe. But the American *Didelphys*,* *Hyænodon*, *Amphicyon*, *Elotherium*, and *Hyopotamus*, with the numerous Chalicotheroid species, show clearly that the White River fauna may be looked upon as a mixture of those of the Stampian and Aquitanian, the former of which is sometimes referred with reason to the Upper Eocene, while the latter is always left in the lowest Miocene. And the solution of this question of position as regards the White River beds appears to me to be at present by no means easy.† According to the system of Naumann, it should be called Oligocene.

Although Artiodactyles with Selenodont molars are far more abundant in both continents during this period than the last, a remarkable difference is to be observed between them. Those of Europe still largely consist of the types with five crescents, as represented by the numerous *Hyopotami* and *Cænotheria*, while in America the modern four-crescent-bearing molar characterizes almost the entire suborder, the only exception being two species of *Hyopotamus*.

The following table will represent the relations of the White River fauna:

STAMPIAN AND AQUITANIAN.

WHITE RIVER.

*Didelphys.**Didelphys.**Protomyidæ.**Leptictidæ.**Protomyidæ.‡**Steneofiber.**Sacommyidæ.§**Steneofiber.**Leporidæ.**Leporidæ.**Hyænodon.**Hyænodon.**Amphicyon.**Amphicyon.**Canis.**Canis.**Temnocyon.**Enhydrocyon.**Gulo.||**Gulo.||**Dinictis.**Machærodus.**Machærodus.**Chalicotheriidæ.**Palæotheriidæ.**Hyracodon.**Aceratherium.**Anchitherium.**Elotherium.**Elotherium.**Palæochærus.**Palæochærus.*

* *Herpetotherium* Cope; *Peratherium* Aym.

† See Ann. Report U. S. Geol. Surv. Terrs. 1873, p. 462, where the White River beds are determined as Lower Miocene.

‡ *Ischyromys* Leidy.

§ *Entoptychus* and *Pleurolicus* Cope.

|| *Amphictis* Pom.

STAMPIAN AND AQUITANIAN.

WHITE RIVER.

*Anthracotherium.**Anoplotheriidae.**Hypotamidae.**Lophiomeryx.**Amphitragulus.**Leptomeryx* (Phosph.).*Dremotherium.**Oreodontidae.**Merycopater.**Pöebrotherium.**Hypertragulus.**Leptomeryx.**Hypisodus.*

The Falunian epoch includes in the large sense the Langhian, Helvetian, and Tortonian divisions, embracing the rich deposits of the Orléanais, of Simorre, and of Sansan. We have here the true Miocene fauna, of which the following genera are characteristic: *Edentata*, *Macrotherium*; Proboscidea, *Dinotherium*, *Mastodon*; Perissodactyla, *Anchitherium*, *Listriodon*; Artiodactyla, *Palæomeryx*, *Dicrocerus*, *Procervulus*; * Carnivora, *Amphicyon*, *Hycænarctos*, ? *Machærodus*; Quadrumana, *Pliopithecus*. The ancient genera *Anthracotherium* and *Cænotherium* continue throughout, and the existing genera *Arvicola*, *Lutra*, and *Sus* appear. The succeeding epoch, the Oeningian, including with it the horizons of Epplesheim and Pikermi, presents the additional genera *Dorcatherium*, *Helladotherium*, several genera allied to *Antilope*, with *Hippotherium*, the huge edentate *Ancylotherium*, and the monkey *Mesopithecus*.

It is from these materials that we must determine by comparison the American Loup Fork epoch, whose deposits are widely spread, and whose fauna is of well-marked character. Although called by my predecessors Pliocene in age, I have insisted that it should be referred to the Miocene series, and I think that the evidence to that effect, which I have produced, will be found conclusive. Nevertheless, here, as in other American Tertiary horizons, the element of geographical peculiarity enters, and diminishes the number of identical types.

FALUNIAN.

LOUP FORK.

*Steneofiber.**Steneofiber.*

Macrotherium. }
Ancylotherium. }

*Morotherium.**Amphicyon.**Amphicyon.* †*Dinotherium.**Cænobasileus.**Tetralophodon.**Tetralophodon.**Aceratherium.**Aphelops.**Anchitherium.**Listriodon.*

* Gaudry, 1878; *Dicrocerus* Cope, 1874 (not Lartet); *Merycodus* et *Cosoryx* Leidy, nomina nuda.

† *Canis ursinus* Cope.

FALUNIAN.

Hippotherium (Oeningian).*Cænotherium*.*Anthracotherium*.*Palæomeryx*.*Dicrocerus*.*Procervulus*.

LOUP FORK.

Hippotherium.*Protohippus*.*Hippidium*.**Oreodontidæ*.*Blastomeryx*.*Procervulus*.*Protolabis*.*Procamelus*.

The existing genera mentioned as found in the Falunian fauna are paralleled by the *Dicotyles*, *Hystrix*, and *Mustela* of the Loup Fork beds. It is evident that this latter horizon retains in its *Oreodontidæ* the same traces of antiquity that the Falunian does in its *Cænotherium*, but shows a more modern aspect in the omission of *Anchitherium* and its replacement by *Hippotherium* and *Protohippus*, and in the still more modern type *Hippidium*. Although but six genera of the two continents are determined as identical in the above table, yet others, which are facing on the same line, are very nearly allied. Other differences are geographical. The *facies* of the Loup Fork horizon is then a compound of that of the Falunian and Oeningian, or Middle and Upper Miocene.

In commenting on the above-described fauna in 1874,† I remarked that "the proper discrimination of American Pliocene remains to be accomplished." It was not long after that date that material for making the identification of this horizon on this continent first came into my hands. This was derived from the superior Tertiary of Oregon, and includes a considerable number of species of fishes, birds, and *Mammalia*. I published a list of some of the species in 1878.‡ The character of the fauna from that region coincides with that which has from time to time been unearthed in the caves and other Eastern deposits to such an extent as to lead us to suspect that the differences between them are geographical only. In Europe, the Pliocene, or Subapennine, includes, according to D'Orbigny (1855) and Gaudry (1878), the Plaisancian and Astian, which are represented at the following localities :

SUBAPENNINE.

Plaisancian.—Montpellier; Casino (Tuscany).

Astian.—Perrier, near Issoir, Coupet, Vialette (Upper Loire), Chagny; English Crag; part of deposits of the Val d'Arno.

The characteristic of this fauna is the fact that the species belong mostly to existing genera, the chief exception being *Hippotherium*. The horses are chiefly represented by *Equus*. Common genera are *Arctomys*,

* *Pliohippus* Marsh.

† Report Lieut. G. M. Wheeler, IV, Palæontology of New Mexico, 1874, p. 364.

‡ Bull. Hayden's U. S. Geol. Surv. Terr. iv, 1878, p. 389.

Lepus, Elephas, Mastodon, Tapirus, Sus, Cervus, Antilope, Bos, Canis, Machærodus, Felis, Ursus. In the *Equus* beds of Oregon, a few extinct genera in like manner share the field with various recent ones, while not a few of the bones are not distinguishable from those of recent species. I give the following list, the extinct species being in italics:

<i>Mylodon sodalis.</i>	<i>Canis latrans.</i>	<i>Auchenia magna.</i>
Thomomys (nr.) clusius.	<i>Elephas primigenius.</i>	<i>Auchenia vitakeriana.</i>
Thomomys talpoides.	<i>Equus occidentalis.</i>	<i>Cervus fortis.</i>
Castor fiber.	<i>Equus major.</i>	
<i>Lutra near piscinaria.</i>	<i>Auchenia hesternæ.</i>	

The species derived from the cave formations of the Eastern States are more numerous, and differ from the Oregon fauna in many respects; yet the parallelism is close in the genera with the *Equus* beds on the one hand and the Pliocene of Europe and South America on the other. The differences distinguishing it from the *Equus* beds of Oregon are, however, such as compel me to regard it as a distinct division of the Pliocene, under the name of the *Megalonyx* beds.

<i>Megatherium</i> (p).	<i>Castoroides.</i>	<i>Machærodus</i> (sp).
<i>Mylodon</i> (p).	Lagomys (s).	<i>Mastodon</i> (sp).
<i>Megalonyx</i> (p).	Lepus (s).	Equus (sp).
Sciurus (s).	<i>Anomodon.</i>	? <i>Hippotherium</i> (s).
Arctomys (s).	Scalops.	Tapirus (s).
Jaculus.	<i>Arctotherium</i> (p).	Dicotyles (p).
Arvicola (s).	Procyon.	Cariacus (p).
Erethizon.	Canis (sp).	Bos (s).
Hydrochærus (p).	Mustela (sp).	

In the above list, the extinct genera are marked in italics. There exists, as a marked feature of the North American Pliocene, to which I called attention several years ago,* a considerable representation of the fauna of the Pampean formation of South America: such are twelve genera, of which six are extinct genera, and four are peculiar to that formation and fauna. The genera found in the Pampean are marked (p), and those of the Subapennine (s). In the list from the Oregon localities, *Mylodon* and *Auchenia* were observed to be the only distinctively Pampean genera. As a conclusion of the comparison of the American *Equus* beds in general with those of Europe, it may be stated that the number of identical genera is so large that we may not hesitate to parallelize them as stratigraphically the same. On the other hand, the agreement with the South American Pampean formation is so marked in some respects as to induce us to believe that the distinction is geographic rather than stratigraphic. Believing that the Pampean formation contains too large a percentage of extinct genera to be properly regarded, as it has been, as Postpliocene or Quaternary, its characters, both essentially and as a result of the comparison which I have been able to make, refer it properly to the Pliocene.

* Proc. Acad. Phila. 1857, 156; Proc. Am. Philos. Soc. 1869, 178.

It appears, then, that the term Pliocene or Subapennine is applicable to the horizon of this fauna in Europe and North and South America.

RÉSUMÉ OF COMPARISONS.

The conclusions to be derived from the facts enumerated in the preceding pages are as follows:

I. Portions of all the faunæ of all the primary divisions of geologic time have been recognized on both the European and North American continents.

II. Parallels requiring general identification of principal divisions of these faunæ may be detected. These are: the Coal-Measures; the Permian; the Laramie; the Maestrichtian; the Eocene; the Miocene.

III. Exact identifications of restricted divisions may be made in a few instances only; such are the Turonian and the Niobrara; the Suessonian and the Wasatch; the *Equus beds* and the Pliocene.

It is not impossible that some of the relations mentioned in II will be by the accession of further information, referrible to the list of exact comparisons in III. In all cases of identification it will be necessary to employ the name first proposed with definition, for the horizon, other names taking places as synonymes. But in the majority of strata it will be necessary to preserve the local names: thus those of Judith River, Bridger, White River, and Loup Fork, applying to beds having no exact equivalents in Europe, cannot be set aside for older ones, but must themselves be applied to corresponding faunal horizons elsewhere, should any such be found in future. And it will rarely happen that the minor subdivisions of such faunæ will be found to have an extent sufficient to warrant their having other than local names.

In the accompanying diagram the series of strata of Europe and North America, as determined by their palæontology, are placed side by side for the purpose of comparison. Complete parallelism can only be predicated of divisions of the first order separated by horizontal lines. Such relation is indicated by exact opposition of the areas representing the epochs in question. In giving the minor divisions of the European epochs I have generally restricted myself to those of the epochs which have American equivalents. Where there is no equivalent on one side or the other, the vacancy is represented by a diagonal line. In employing names for epochs and their divisions, I have adhered to the law of priority as far as my knowledge of the literature allows.* I have given a few names to American formations, but only in instances where such had not been previously given. In such cases I have preferred employing the name of some characteristic genus of fossils, rather than one of local origin.

* In the European system I have been much aided by the atlas of Prof. Renevier of Lausanne, and by the writings of Woodward, Gervais, Hébert, Pomel, Gaudry, Filhol, etc.

WEST EUROPE.			NORTH AMERICA.	
Astian.	Pliocene.	Tertiary.	Pliocene.	Equus beds.
Plaisancian.				Megalonyx beds.
Oeningian.	Oeningian.		Loup Fork.	Procamelus beds.
Tortonian.	Falunian.			Ticholeptus beds.
Langhian.			Aquitanian.	Oregon beds.
Aquitanian.	Tongrian.		White River.	White River.
Stampian.	Parisian.		Uinta.	Uinta.
Sestian.			Bridger.	Bridger.
Bartonian.			Wasatch.	Green River.
Bruxellian.	Wasatch.			
Suessonian.	Suessonian.			
Thanetian.	Thanetian.	Post-cretaceous.	!Puerco.	Puerco.
			Laramie.	Fort Union. Judith River.
Maestrichtian.	Senonian.	Cretaceous.	Fox Hills.	Fox Hills.
Campanian.				Fort Pierre.
Santonian.			Colorado.	Niobrara.
Turonian.	Fort Benton.			
Carentonian.	Cenomanian.		Dakota.	Dakota.
Rhotomagian.				
Vraconian.	Gault.			
Albian.	Urgaptian.			
Aptian.				
Rhodanian.				
Urgonian.				
Hauterivian.	Wealden.	Jurassic.	Camarasaurus beds.	
Valangian.				
Purbeckian.	Portland.			
Portlandian.				
Kimmeridgian.				
	Corallian.			
	Oxfordian.			
	Bathian.			
	Upper Lias.			
	Lower Lias.			

WEST EUROPE—Continued.		NORTH AMERICA—Continued.		
	Rhaetic.	Trias.		
Karnian.	Keuper.		Keuper.	
Norian.				
	Muschelkalk.			
Thuringian.	Permian.	Carboniferous.	Permian.	Clepsydrops shales.
Lodevian.			Eryops beds.	
Coal-Measures.	Coal period.		Coal period.	Coal-Measures.
Conglomerate.				Conglomerate.
Mountain limestone.				Mountain limestone.
Fammenian.	Upper Devonian.		Upper Devonian.	Catskill.
Eifelian.	Middle Devonian.			Chemung.
				Hamilton.
Coblentzian.	Lower Devonian.		Lower Devonian.	Corniferous.
				Oriskany.
Ledburian.	Upper Silurian.	Upper Silurian.	Lower Helderberg.	
Ludlovian.			Salina.	
Wenlockian.			Niagara.	
Llandoveryan.	Lower Silurian.	Lower Silurian.	Hudson.	
Caradocian.				
Llandeillian.			Trenton.	
Tremadocian.				
	Primordial.	Primordial.	Calcliferous.	
			Potsdam.	
		Archaean.		

The oldest of these I have called the *Eryops* beds, from the most abundant genus of Labyrinthodonts which is found in it. They contain, also, abundance of other *Vertebrata*, none of which are higher than *Reptilia* (order *Theromorpha*), with plants, mollusks, etc. They consist of sandstones, alternating with beds of red clay and coarse conglomerate and sphærosiderite, etc. They are chiefly distributed in Northern Texas and Southern Indian Territory.

The *Clepsydropis* shale, named by me in 1865, forms a thin stratum, in Southeast Illinois and Southwest Indiana, consisting of black and rarely reddish carbonaceous shales and clays. These appear in some places to lie conformably on the Coal-Measures, to which they have been referred by previous geologists, but Collett, Gibson, and others have shown that it is unconformable over considerable areas. It does not belong to the Coal-Measures.

The Puerco marls were first observed by me in New Mexico in 1874, and afterwards found to have an extensive development in Southwestern Colorado, by Endlich, in 1875. He has referred them to the lowest place in the Tertiary series, but the absence of fossils renders it difficult to conclude whether they belong here or in the Laramie series.

The Oregon White River beds differ from those found east of the Rocky Mountains, although they contain a majority of the same genera, and many of the same species. They are wanting in the important genera *Symborodon* and *Menodus*. To represent these genera, they have *Dæodon*, and, in addition, some peculiar genera of *Rodentia*, as *Entoptychus*, *Pleurolicus*, and *Meniscomys*, and the Suilline *Palæochærus*. Among Carnivora, the genus *Enhydrocyon* is, so far as known, characteristic of them.

The Loup Fork beds are represented in the valley of Smith's River, Montana, by a horizon which may be somewhat older than that heretofore known. The fauna presents us with the typical genera *Procamelus*, *Hippotherium*, *Protohippus*, *Mastodon*, and *Merycochærus*, but, in addition, with the peculiar genera of *Oreodontidæ*, *Ticholeptus*, *Cyclopidius*, and *Pithecistes*,* and with Ruminants similar to *Palæomeryx*. These are wanting from the other parts of the formation, and I therefore name the two divisions the *Ticholeptus* and the *Procamelus* beds.

I have already mentioned the *Megalonyx* beds as the equivalents in the east of North America of the *Equus* beds of Oregon and California, but which present such important differences that they cannot be identified. The differences are displayed in the catalogues already given, the list of the *Megalonyx* fauna having been derived from the exploration of caves in Pennsylvania†, Virginia, and Illinois. The remains of this fauna are by no means found in caves only, but are found in swamps and Pliocene clays. The extinct genera characteristic of the *Megalonyx* beds are *Megatherium*, *Megalonyx*, *Castoroides*, and *Arctotherium*; the genera no longer living in North America, *Hydrochærus*, *Tapirus*.

* Proc. Am. Philos. Soc. 1877, p. 219.

† Loc. cit. 1871, p. 73.

In conclusion, it may be observed that the lacunæ in the series as presented by one continent render us dependent on the other for the evidence necessary for the complete elucidation of the laws of the creation of animal life. Phylogenies can be thus constructed which would otherwise be impossible, and the results of researches into the earliest types of *Vertebrata* become intelligible. Thus I have been able to prove, in support of a thesis published in 1874, that the earliest Ungulate *Mammalia* were pentadactyle and plantigrade. I have also shown that the ankle-joint had not, in the primitive *Mammalia*, the hinge-like character that it has in the later ones, but that it is without the interlocking superior articulation. The small size of the brain of early *Mammalia*, already pointed out by Lartet, has received extensive confirmation by the researches of Marsh, who has also shown the progressive increase in size of the whole body in various Mammalian lines. To these results I now add another, which is derived from the study of numerous Permian *Vertebrata*, viz, that the earliest land vertebrates had a persistent chorda dorsalis.

COMPARISON WITH THE SCALE DERIVED FROM PALÆOBOTANY.

I now consider another kind of relation presented by the American and European horizons. I allude to the floræ, for my knowledge of which I am necessarily dependent on the labors of others. I first exhibit the determinations of the ages of the American formations already discussed, made by Mr. Lesquereux on the basis of the vegetable remains which they contain. I place by the side of these my own determinations of the ages of the same beds, as already related. The former are derived from the full memoir of Mr. Lesquereux in the Annual Report of the United States Geological Survey of the Territories for 1872, pp. 410-417. It will be observed that there is a constant discrepancy between the two tables.

Lesquereux.	Formation.	Cope.
.....	Loup Fork	Miocene.
.....	White River.....	Oligocene.
Upper Miocene	Bridger	Middle Eocene.
Miocene.....	{ Wasatch	Lower Eocene.
	{ Green River	
Lower Eocene	Laramie	Upper Cretaceous.

If the determinations of Mr. Lesquereux be correct,* it is evident from the above that the vegetable life of North America reached its present condition one epoch or period earlier than the higher *Vertebrata*, and that the nomenclature is thus thrown back by so much. It would appear that the recent flora of North America is a period older than the

*The above parallels are well presented by Dr. Peale in his report to Dr. Hayden, Ann. Rept. U. S. Geol. Surv. Terrs. 1874, p. 141 *et seq.*

fauna, *i. e.*, has persisted longer than the latter by a certain length of geologic time. Applying the same reasoning to the past, I embodied the idea in reference to the Laramiè period ("Fort Union") in the statement that "a cretaceous fauna was then contemporary with a tertiary flora"; and, later, that "an eocene fauna was contemporary with a miocene flora." It may have to be added that a miocene fauna was contemporary with a pliocene flora. Since Mr. Lesquereux has the support of the best palæobotanists of Europe, in his conclusions, it is useless to take the ground assumed by a few of my colleagues, that the former gentleman has simply erred in his determinations. He gives us grounds for believing that he has not done so, by giving us the European standard by which his identifications are governed.* It is as follows:

Pliocene.	Lower limits not positively fixed; largely developed in Italy. ? (Subapennine, E.D.C.)
Miocene.	Oeningian; Mayencian; Aquitanian.
Oligocene ...	Tongrian.
Eocene.	Gypse of Aix; Alum Bay; Mt. Bolca; London Clay; Sheppey; Grès of the Sarthe.
Paleocene. . .	{ Upper Landenian; Sezanne (= Paniselian).
	{ Suessonian (Lignitic Soissonais; Sables de Bracheux); Lower Landenian.
	{ Hersian; Gelinden. Limestone of Mons, overlying unconformably the Maestrichtian.

This system, it will be observed, is almost exactly identical with that employed in the preceding pages as the standard of comparison for the *Vertebrata*. Yet it has resulted, from a most careful comparison of both faunæ and floræ of America with this standard scale, that two distinct palæontological series have to be adopted, the one for the vertebrate life and the other for the plants of the Western Continent. If this result be accurate, and there appears to be no avoiding it, an explanation must be sought. There are only two possible ones: either the animal life of North America has lagged behind that of Europe by one period during past geologic time; or, secondly, the vegetable life of America has been equally in advance of that of Europe during the same period. In other words, if the plant-life of the continents was contemporaneous, ancient types of animals remained a period longer in North America than in Europe. If animal life was contemporaneous, plant-life had advanced by one period in Europe beyond that which it had attained in North America. In either case, the faunal or the floral standard of estimation of geologic age of strata for North America is a false one, since there can be but one standard of comparison for anything. But this great fact being understood, the evidence of each of the great departments of life possesses its own intrinsic value.

* Ann. Report U. S. Geol. Surv. Terrs. 1874, p. 235.

Art. III.—Observations on the Faunæ of the Miocene Tertiaries of Oregon.

By **E. D. Cope.**

A considerable number of *Vertebrata*, almost exclusively *Mammalia*, have been described by authors from the White River and Pliocene formations of Oregon. The descriptions are found in Professor Leidy's contribution to the Final Report of the United States Geological Survey under Dr. Hayden (Vol. I); in those of Professor Marsh in the *American Journal of Science*; in a paper by Mr. Bettany in the *Quarterly Journal of the Geological Society of London* for 1876; and in a paper by myself (*Paleontological Bulletin* No. 30) in the *Proceedings of the American Philosophical Society*, published in December, 1878.* Having recently had the opportunity of inspecting a considerable amount of material from the horizons in question, I give a list of the species which I have observed. A few new ones occur in collections received since the publication of my last paper, and are now described, together with some of interest from the Loup Fork beds of the same region.

White River Fauna.

TESTUDINATA.

STYLEMYS OREGONENSIS Leidy.

RODENTIA.

STENEOFIBER GRADATUS Cope.

STENEOFIBER ? NEBRASCENSIS Leidy.

MENISCOMYS HIPPODUS Cope.

MENISCOMYS MULTIPLICATUS Cope.

PLEUROLICUS SULCIFRONS Cope.

ENTOPTYCHUS CAVIFRONS Cope.

ENTOPTYCHUS PLANIFRONS Cope.

ENTOPTYCHUS CRASSIRAMIS Cope.

PALÆOLAGUS HAYDENI Leidy.

* See also the *American Naturalist*, December, 1878.

CARNIVORA.

HOPLOPHONEUS BRACHYOPS Cope.

MACHÆRODUS STRIGIDENS Cope.

ENHYDROCYON STENOCEPHALUS, gen. et sp. nov.

Generic Characters.—Dental formula: I. $\frac{1}{1}$; C. $\frac{1}{1}$; Pm. $\frac{3}{3}$; M. $\frac{2}{2}$. The superior premolars consist of two ordinary and one sectorial; the first and second are both compressed, two-rooted, and in the typical species with median lobe of posterior cutting edge. The two true molars are transverse and tubercular. The three inferior premolars are all two-rooted, and with posterior lobe in the two known species. The heel of the sectorial is cutting, as in *Temnocyon*, and the internal tubercle is present. There is at least one inferior tubercular tooth; specimens are injured so as not to display a second.

In a nearly complete cranium belonging to the typical species of this genus, we observe the shortness of the facial part of the skull as compared with the length of the cerebral, and also the constriction of the skull behind the orbits. The zygomatic arches are robust and expanded, and the sagittal crest is high. The auditory bullæ are inflated and thin-walled.

The dentition of this genus refers it to the *Canidæ*, but the form of the skull resembles that of *Putorius vison* and *Lutra*.

Specific Characters.—The principal cusps of the inferior premolars present cutting edges, as does the median posterior lobe. In both third and fourth there is a small conic heel posteriorly, but an anterior basal tubercle on the fourth only. The sectorial is large and robust, and the heel is short, with an absolutely median cutting edge. The first tubercular is longer than wide, and presents a nearly median cusp in front, which is joined to a low one on the internal border of the crown.

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The cranium is remarkable for the anterior position of the orbits, and the associated shortening of the face and lengthening of the parietal region. The orbits look somewhat forwards and very little upwards. The superciliary region is slightly prominent, and there is a prelacrymal concavity. The infraorbital foramen is moderate, and is situated mostly above the posterior part of the fourth premolar. The muzzle is flat

CARNIVORA.

HOPLOPHONEUS BRACHYOPS Cope.

MACHÆRODUS STRIGIDENS Cope.

ENHYDROCYON STENOCEPHALUS, gen. et sp. nov.

Generic Characters.—Dental formula: I. 3; C. 1; Pm. 3; M. 2. The superior premolars consist of two ordinary and one sectorial; the first and second are both compressed, two-rooted, and in the typical species with median lobe of posterior cutting edge. The two true molars are transverse and tubercular. The three inferior premolars are all two-rooted, and with posterior lobe in the two known species. The heel of the sectorial is cutting, as in *Temnocyon*, and the internal tubercle is present. There is at least one inferior tubercular tooth; specimens are injured so as not to display a second.

In a nearly complete cranium belonging to the typical species of this genus, we observe the shortness of the facial part of the skull as compared with the length of the cerebral, and also the constriction of the skull behind the orbits. The zygomatic arches are robust and expanded, and the sagittal crest is high. The auditory bullæ are inflated and thin-walled.

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at each extremity of the crown; its base is expanded posteriorly. The principal cusp of the third premolar is more elevated, and, besides the anterior and posterior tubercles, there is a basal posterior heel, which is continued as an expansion of the inner base of the crown. In the fourth premolar, the base of the crown is expanded, especially posteriorly; the principal cusp has a nearly circular section at the base, and the posterior median lobe is a subconic tubercle standing on the middle of the heel. The sectorial is large and relatively rather narrow, but the details of its form are not ascertainable.

Measurements.

	M.
Length of dental series, including canine and sectorial.....	0.076
Length of the base of the sectorial	0.024
Length of the premolar series.....	0.037
Length of the fourth premolar.....	0.016
Width of the fourth premolar.....	0.009
Length of the third premolar.....	0.013
Width of the third premolar.....	0.008
Length of the second premolar	0.009
Width between centres of crowns of fourth premolars	0.034
Length of symphysis	0.035

This species was probably of the dimensions of the Gray Wolf. Found by Mr. Sternberg in the same region as the *E. stenocephalus*,

TEMNOCYON ALTIGENIS Cope.

CANIS HARTSHORNIANUS Cope

CANIS GEISMARIANUS Cope.

CANIS CUSPIGERUS Cope.

CANIS LIPPINCOTTIANUS Cope.

CANIS GREGARIUS Cope.

PERISSODACTYLA.

DÆODON SHOSHONENSIS Cope.

ACERATHERIUM PACIFICUM Leidy.

ANCHITHERIUM EQUICEPS Cope.

ANCHITHERIUM BRACHYLOPHUM Cope.

ANCHITHERIUM LONGICRISTE Cope.

ARTIODACTYLA.

ELOTHERIUM IMPERATOR Leidy.

PALÆOCHÆRUS CONDONI Marsh.

PALÆOCHÆRUS PRISTINUS Leidy.

PALÆOCHÆRUS SOCIALIS Marsh.

MERYCOPATER GUYOTIANUS Cope.

EUCROTAPHUS SUPERBUS Leidy.

EUCROTAPHUS OCCIDENTALIS Marsh.

MERYCOCHÆRUS LEIDYI Bettany.

MERYCOCHÆRUS TEMPORALIS Bettany.

POËBROTHERIUM STERNBERGII, sp. nov.

This Ruminant is represented by a considerable part of the skeleton with both mandibular rami supporting the teeth, of one individual. The bones are all in close proximity, and sometimes in undisturbed relation, in a single block of stone.

The species to which I give the above name presents the characters already ascribed to the genus *Poëbrotherium* by Leidy as regards cranial features, and by myself as regards the rest of the skeleton. The third and fourth metacarpals are not coössified, and the second and fifth are not distinguishable. The preservation of the premaxillary bone in this species enables me to demonstrate the presence of superior incisor teeth, a character the presence of which I have heretofore only inferred. As compared with the *P. vilsoni*, the species differs in its superior size and greater relative robustness. This is seen in the greater depth of the mandibular ramus, and the greater stoutness of the metapodial and other limb-bones. The last inferior molar tooth presents a characteristic peculiarity. The anterior external cusp is separated by a deep groove which divides the external side of the crown to the base from the succeeding cusp. It results that on trituration, the anterior external crescent is isolated, and does not communicate by its posterior horn with the succeeding crescent, as in *P. vilsoni*. The last premolar is more robust than that of the *P. vilsoni*, the width of the half-worn surface being half the length of the tooth and enclosing behind an enamel fossa. In *P. vilsoni*, this tooth is more compressed, and the fossa is represented by an open groove. The first inferior premolar occupies the middle of the diastema following the canine, instead of standing near the canine as in *P. vilsoni*.

Measurements.

		M.
Diameter of last molar	{	antero-posterior..... 0.020
		transverse
Diameter of penultimate molar..	{	antero-posterior
		transverse
Depth of ramus at second molar		0.025
Length of ramus from third molar to extreme posterior edge.....		0.061
Length of metacarpus		0.178
Transverse proximal diameter of the two metacarpi		0.029
Greatest diameter of the head of the humerus		0.053
Antero-posterior diameter of the condyle of the femur.....		0.048

This species is named in honor of Charles H. Sternberg, the indefatigable explorer of the fossil deposits of the West.

BOÛCHÆRUS HUMEROSUS, gen. et sp. nov.

Generic Characters.—The species on which this genus is founded, is represented by a part of the skeleton, which is unfortunately not accom-

panied by cranial bones or teeth. The characters are, however, sufficiently clear for purposes of determination. The great tuberosity of the humerus is produced beyond the head, and does not close round the bicapital groove. The intertrochlear ridge is well developed, and there is no internal epicondyle; the external epicondyle is moderately developed. On the carpal extremity of the ulno-radius, the facets of the scaphoid, lunar, and cuneiform bones, are distinguished by strong oblique ridges, and the last named is nearly in the horizontal line of the two others. In the carpus, the trapezoides is distinct, and the trapezium wanting. The unciform is in contact with the lunar. Metacarpals two, distinct from each other, with free rudiments of the second and fifth at their proximal extremities. Their distal keels confined to the posterior faces of their extremities. Phalanges depressed; unguis short, obtuse.

In the above description is found a combination of characters not known to me to exist in any recent or extinct genus of *Artiodactyla*. Several of its features indicate affinity to the suilline division, while others point to the *Ruminantia*. The imperfect distal articulation of the metacarpals is characteristic of the extinct types *Oreodontidæ* and *Poëbrotheriidæ*, and the two distinct metacarpals constitute the resemblance to the latter family the stronger. The latter character is, however, not inconsistent with the *Omnivora*, and the depressed phalanges add to the weight of affinity in this direction. The distal extremity of the humerus is much like that of a peccary. The distal articular surface of the ulno-radius points, however, again to the *Ruminantia* of the group *Pecora*, displaying a specialization quite in contrast with the primitive character of the metacarpo-phalangeal articulation. From these considerations it can be seen that it is not easy to affirm whether this genus possesses bunodont or selenodont dentition. If I may venture an inference as to the affinities of the genus, I would suggest that it will be found to be as nearly allied to the *Hypertragulidæ* as to the *Oreodontidæ*, though not without suilline affinities.

Specific Characters.—The only species of this genus known to me is of large size. It is represented by the greater part of a scapula and both anterior limbs and feet; by the pelvis, femur, and part of tibia, and by some vertebræ; all found in immediate association by Mr. Sternberg. These remains indicate an animal of the size of the *Rhinoceros indicus*. The animal is characterized by the massive proportions of the humerus as compared with the femur, and by the short, robust form of the metacarpals.

In the *humerus*, the external border of the great tuberosity is entire, and is not reverted, but descends backwards like the remainder of the surface. The apex of the great tuberosity is much recurved, rising steeply proximad of the head. The bicapital groove is deep. The lesser trochanter is large and simply conic; its transverse extent is not great. External to its base is a small tuberosity, which is represented in *Bos*, but not in *Dicotyles* or *Sus*. The deltoid crest is very prominent, de-

latter is subtriangular in outline, its apex being the point of conjunction of the scapho-lunar ridge with the internal border, just posterior to its greatest convexity. Its superior boundary is interrupted by the wide groove which separates the median ridge from the internal border of the distal part of the radius.

Measurements of the Ulna-radius.

	M.
Transverse diameter, total	0.110
Transverse diameter of ulna	0.050
Antero-posterior diameter of articular face	{
externally	0.035
at middle of ulna	0.021
at luno-cuneiform ridge	0.055
internally	0.045

But for the extent and transverse position of the ulnar portion of this articular face, it might be regarded as pertaining to a typical Ruminant.

The length of the *carpus* is about three-fourths its width, the proximal elements being larger than the distal. A feature of its anterior face is the close approximation of the inferior angle of the lunar to the superior angle of the third metacarpus, which allows the magnum and unciform a very slight contact. The external face of the scaphoid is chiefly lateral; its posterior border is a vertical, short tuberosity. The proximal face is abruptly decurved at the anterior outer angle, to meet the lunar. There are two separate oval superior lunar facets, and one narrow anterior inferior one. The inferior face is nearly equally divided by a low cross ridge which fits a concavity of the posterior part of the magnum. The lunar is the largest bone of the carpus. Its proximal face is decurved anteriorly, posteriorly, and on each side, and is twice as long as wide at the middle. The postero-internal and antero-external angles are produced, the latter into a compressed process which articulates with the adjacent angle of the cuneiform. Besides this facet there is one other for the cuneiform, which occupies the posterior half of the inferior part of the outer side, and is separated from the superior edge by a deep groove. The unciform facet is in front nearly as wide as that of the magnum, but grows gradually narrower posteriorly. The facet for the magnum is concave, and grows very wide posteriorly, with the posterior internal angle produced downwards. The proximal facet of the cuneiform is very concave, the anterior and posterior borders being elevated, and the internal and external decurved; the latter prolonged a little backwards. Below this extremity on the external aspect is a fossa. The pisiform facet makes an angle of 90° with the ulnar, and extends behind and along the posterior edge of the latter to its apex. The unciform facet is simple, and is in shape a right-angled triangle with convex hypotenuse. The posterior aspect of this bone is concave.

The proximal face of the trapezoides is longer than wide, convex antero-posteriorly, and subdiamond-shaped. The inferior face is narrow subdiamond-shaped, and has less than half the area of the proximal. There is a small round tuberosity on the posterior border, and no trace

of facet for a trapezium. The anterior face of the magnum is wider than long, and is divided into three planes. The proximal extremity is divided into two areas by a high antero-posterior keel. The inner area is the larger, and is bounded by the entire superior border of the anterior face of the bone. The outer area, or the lunar facet, extends very obliquely downwards, most so in front, where it forms the external side of the magnum. It is interrupted by a large sinus, which leaves the posterior portion of the face narrow and transverse. Behind it is first a fossa and then two short tuberosities, one above and external to the other. The inferior face is undivided, and is concave antero-posteriorly, and convex transversely. The unciform is the second bone of the carpus in size. Its anterior face is broader than long, and is convex transversely. The inner face has in front a large trapezoidal facet for the third metacarpus, which is only separated from that of the lunar by the angle. The superior face is divided, by an angular ridge nearly parallel with the inner border, into two unequal faces for the lunar and cuneiform. The latter is half as wide posteriorly as long, and terminates anteriorly in an obtuse angle. The distal face is undivided, but is recurved postero-externally, apparently offering a narrow facet for the fifth metacarpus. This face nearly meets the cuneiform face posteriorly. Behind both the unciform is produced into a decurved, subconic tuberosity.

*Measurements of the Carpus.**

		M.
Diameter of scaphoid	{ antero-posterior	0.066
	{ longitudinal	0.048
Diameter of proximal face of scaphoid	{ antero-posterior	0.048
	{ transverse	0.030
Diameter of distal face of scaphoid	{ antero-posterior	0.048
	{ transverse	0.023
Diameter of proximal face of lunar	{ transverse .. { anteriorly	0.047
	{ .. { at middle	0.032
	{ longitudinal	0.053
Diameter of anterior face of lunar	{ longitudinal	0.048
	{ transverse	0.032
Diameter of cuneiform	{ antero-posterior, oblique	0.059
	{ transverse, behind	0.040
Diameter of proximal face of cuneiform	{ antero-posterior	0.040
	{ transverse	0.044
Diameter of distal face of cuneiform	{ antero-posterior	0.040
	{ transverse	0.031
Length of trapezoides		0.027
Diameter of proximal face of trapezoides	{ antero-posterior	0.029
	{ transverse	0.016
Diameter of distal end of trapezoides	{ antero-posterior	0.020
	{ transverse	0.010
Diameter of magnum	{ longitudinal { anteriorly	0.029
	{ .. { externally	0.040
	{ transverse, posteriorly	0.047
	{ antero-posteriorly, outer side	0.055

*These measurements are always the greatest, and are axial, or in straight lines.

Measurements of the Carpus—Continued.

	M.
Diameter of lunar face of magnum.....	{ antero-posteriorly 0.046
	{ transversely 0.031
Diameter of distal face of magnum	{ antero-posteriorly 0.040
	{ transversely 0.048
Diameter of unciform	{ antero-posterior 0.080
	{ transverse 0.053
	{ longitudinal, in front..... 0.040
Diameter of lunar facet.....	{ antero-posterior 0.047
	{ transverse (least)..... 0.016
Diameter of cuneiform facet.....	{ antero-posterior 0.052
	{ transverse (behind)..... 0.028
Diameter of 4th metacarpal facet.....	{ antero-posterior 0.044
	{ transverse..... 0.046

As already remarked, this carpus displays resemblances to some recent types, and possesses some which are not known among living *Artiodactyla*. The inferior face of the scaphoid is narrower from side to side than in the *Ruminantia* or *Sus*, *Dicotyles* only approaching but not equalling it in this respect. The strong inferior keel of the lunar exceeds that seen in any of the *Ruminantia* or *Omnivora*. The pisiform facet is more oblique than in those groups. The posterior tuberosities of the magnum and unciform are larger than those of the genera of either group, while the distinct trapezoides, the slightly shortened magnum and unciform, and slight decurvature of the cuneiform facet of the unciform posteriorly, are suilline characters.

The *metacarpals* are robust, but flattened antero-posteriorly. The rudiments of the second and fifth are free, and the latter is the larger. The third has a considerable surface of contact with the unciform; its anterior face displays two shallow fossæ, one at each superior angle. The corresponding positions on the fourth metacarpal are occupied by two low bosses. Otherwise the surfaces of the shafts of these bones are uniform. The phalangeal articular face is well reverted anteriorly and posteriorly, and is not bounded by a transverse depression anteriorly above. The carina is short, though prominent, and extends to the middle of the distal extremity. The lateral distal tuberosities are very low.

Measurements of the Metacarpals.

	M.
Length of M. III.....	0.210
Length of M. IV	0.190
Diameter of M. III proximally.....	{ transverse (total)..... 0.063
	{ antero-posterior 0.055
Diameter of M. III distally	{ transverse 0.053
	{ antero-posterior (chord)..... 0.045
Diameter of M. IV proximally	{ transverse 0.054
	{ antero-posterior 0.045
Diameter of M. IV distally.....	{ transverse..... 0.043
	{ antero-posterior (chord)..... 0.048
Length of M. II.....	0.055
Length of M. V.....	0.040
Diameter of M. V antero-posteriorly.....	0.021

The *phalanges* are more depressed than in any genus of *Artiodactyla* known to me, excepting *Hippopotamus*. The proximal articular surface of the first is gently concave, with the anterior border not produced. The shaft is not contracted, and is regularly convex above or anteriorly. The distal articular face is narrower above and not produced. The superior border of the proximal face of the second phalange is produced medially. The distal face is narrowed and produced upwards, so as to stand in high relief, from which it results that the middle of the shaft is very concave above. The external and internal borders of the inferior or posterior part of the distal face, are produced backwards, covering lateral basal ridges of more than half the length of the shaft, which form the inferior border of lateral fossæ. One unguis is preserved. It is distinct in form from that of *Hippopotamus*, *Sus*, or *Dicotyles*, and resembles that of the llama. It is short, obtuse, and compressed. The external face is nearly plane fore and aft, and slightly convex vertically. The inner is convex fore and aft, and concave vertically. The profile descends steeply to the apex, the curve commencing but little beyond the base. The inferior face is at right angles to the interior face, and is moderately wide.

Measurements of the Phalanges.

	M.
Median length of first of M. IV	0.066
Proximal diameter	{ antero-posterior 0.042
	{ transverse 0.055
Distal diameter	{ antero-posterior (median) .. 0.030
	{ transverse (greatest)..... 0.055
Median length of second phalange	0.055
Diameter of second phalange proximally	{ antero-posterior 0.035
	{ transverse 0.045
Diameter of second phalange distally	{ antero-posterior 0.032
	{ transverse 0.041
Length of ungual phalange below	0.042
Proximal diameter of ungual phalange	{ antero-posterior 0.032
	{ transverse 0.025

The *femur* is slender as compared with the humerus, and of moderate length. The great trochanter is produced, but not beyond the line of the convexity of the head, and is not much recurved. The expanse externally is about as great as that of the head internally. The trochanteric fossa is not large, and is cut off below by a plane surface at the base of the great trochanter, whose superior border forms a curved line connecting the great and little trochanters. The latter is large and projects well inwards. The *fossa ligamenti teris* is large and central, having no connection with the border of the head of the femur. The posterior side of the shaft is flat, and the anterior face regularly convex. The two faces meet externally in a well-marked representative of the *linea aspera*. The rotular face of the femur is short and wide, with the borders somewhat oblique, and the inner edge is higher than the outer at its proximal part. It is strongly convex from above downwards, and

in the incompleteness of the trochlear keel of the metapodials, and the trenchant character of the premolars, excepting the last.

The species of the preceding list which I have observed in other localities are the following, which I procured in the White River beds of Eastern Colorado: *Palæolagus haydeni*, *Canis hartshornianus*, *Canis lippincottianus*, *Canis gregarius*, *Leptomeryx evansi*, *Hypertragulus calcaratus*. Professor Leidy has recognized a number of species as those previously found in the White River beds of Dakota by Dr. Hayden.

Loup Fork Fauna.

Two new species were obtained by Mr. Sternberg at this horizon, which present characters of considerable interest. They are as follows:
LUTRICTIS? LYCOPOTAMICUS, sp. nov.

This Carnivore is represented by a left mandibular ramus, which contains alveoli and crowns of the canine and molars, excepting those posterior to the sectorial. These teeth have the formula, four premolars, of *Mustela* and of the Dogs, but the sectorial is much more like that of *Lutra* than that of either of the genera named. The heel of this tooth is long, and encloses a wide space transversely, while the sectorial portion is short and low, and includes a large internal tubercle. In the absence of the tubercular teeth, the generic reference is uncertain; but its characters agreeing, so far as they go, with the genus *Lutricitis* of Pomel, I refer it there provisionally.

The first premolar only is one-rooted; the third is wide behind, developing a low heel. The heel of the fourth is a little better developed, and there is a small anterior basal cutting lobe; there is also a tubercle on the posterior cutting edge at the middle. The three cusps of the anterior part of the sectorial tooth are situated at the corners of an imaginary equilateral triangle. The heel continues the width of the crown, is wider than long, and is abruptly truncate behind. It supports a long cutting edge just within the external border, and a shorter one on the internal. The surface of the enamel is smooth. There are two mental foramina, one below the interval between the first and second premolars, the other beneath the anterior root of the third premolar.

Measurements.

	M.
Length of molar series without tubercular	0.0220
Diameter of sectorial { antero-posterior	0.0066
{ transverse	0.0040
Length of heel of sectorial	0.0024
Length of fourth premolar	0.0045
Elevation of fourth premolar	0.0036

From the Loup Fork formation of Cottonwood Creek, Oregon; discovered by Charles H. Sternberg.

PROTOLABIS TRANSMONTANUS, sp. nov.

A nearly complete cranium, without lower jaw, of an adult animal, is

the basis of our knowledge of this species. It presents the characters of the genus in the following superior dental formula: I. 3; C. 1; P.m. 4; M. 3. The first premolar is situated in the middle of a long diastema, and a short one separates the canine from the third incisor.

On comparison of this species with the *P. heterodontus*, the type, and heretofore the only known species of the genus, various characteristic peculiarities may be observed, which will be noticed in the course of the description. It is considerably smaller than the *P. heterodontus*, resembling in its dimensions the *Procamelus occidentalis*.

The crown of the second superior incisor is directed forwards, and the cutting edge is oblique to the long axis of the tooth. The first incisor is equally large, and its alveolus occupies the apex of the premaxillary bone. In *P. heterodontus*, the alveolus is smaller, and the apex extends considerably beyond it. The third incisor has a conic crown, with sub-round section. In *P. heterodontus* it is more robust, and is oval in section, with weak posterior cutting edge. The canine is less robust than the third incisor, and is about as far posterior to it as the latter is from the second incisor. The crown is slightly compressed, and is less robust than that of *P. heterodontus*. The first premolar is still weaker, and the crown is compressed; the roots are only discrete at their extremities. It is situated a little more than one-third the distance between the canine and second premolar behind the former. The second premolar is well developed, and is two-rooted. The third premolar is also large, with the grinding surface of the crown about half as wide as long. It has a strong internal basal cingulum, which on attrition encloses a groove-like fossa with the principal crown. The external face of the crown is gently convex between an anterior and a posterior ridge. The internal face of the crown is uniformly convex. The fourth premolar has both crescents well developed. Its grinding face is subsemicircular, and there are a strong anterior and a weak posterior external vertical ridge. In *P. heterodontus*, the grinding surface of this tooth is more nearly subquadrate.

The true molars are subquadrate in horizontal section, and have short crowns, well distinguished from the roots. The anterior horn of each external crescent is prolonged, constituting a section of a prominent vertical external ridge of the crown at each point. The external sides of the columns are but slightly convex. The inner sides of the internal columns are strongly convex. The enamel borders of the lakes are absolutely simple, and there are no included enamel fossæ. The posterior outer angle of the last superior molar is not produced.

As compared with the true molars of *P. transmontanus*, those of the *P. heterodontus* are relatively smaller in transverse diameter. The masticating surfaces of the crowns of the second and third are thus more elongate in outline. They are also rather more prismatic, and the last two apparently occupied longer time in the process of protrusion. They are much larger than those of *P. transmontanus*.

The *foramen infraorbitale* issues above the middle of the fourth pre-

molar. In *P. heterodontus* it issues above the anterior part of the first true molar. A sharp angle separates the exterior and extero-inferior faces of the malar bone.

Measurements.

	M.
Length of dental series from base of first incisor	0.257
Length of incisors on chord	0.028
Space between third incisor and canine	0.006
Length of crown of third incisor	0.013
Antero-posterior diameter of third incisor	0.008
Length of interval between canine and first premolar	0.011
Length of interval between first premolar and second premolar	0.020
Length of three contiguous premolars	0.035
Length of third premolar	0.014
Width of third premolar (greatest)	0.0075
Length of true molar series	0.057
Diameter of second true molar { antero-posterior	0.018
{ transverse	0.018
Diameter of third true molar { antero-posterior	0.022
{ transverse	0.019

Discovered by C. H. Sternberg in the Loup Fork beds of Cottonwood Creek, Oregon.

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PAT. JAN. 21, 1908



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