GLOSSARY AND CORRELATION CHARTS OF NORTH AMERICAN TERTIARY MAMMAL-BEARING FORMATIONS

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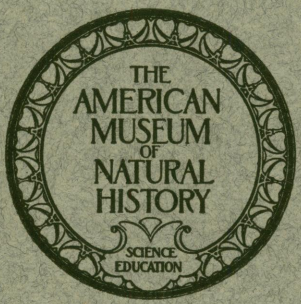

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Article III.—GLOSSARY AND CORRELATION CHARTS OF NORTH AMERICAN TERTIARY MAMMAL-BEARING FORMATIONS

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INTRODUCTION

There are over one hundred thirty names in more or less common use for American Tertiary mammalian faunas and the formations that contain them. Some of these, like "Wasatch" or "Loup Fork" are old and classic, known to every geologist, while others, like "Duchesne" or "Tehama" have only recently been recognized and are as yet known only to a few specialists. Whether old or new, the use and meaning of these names often present peculiar difficulties. The classic names, particularly including the two mentioned, have had such checkered careers and have been used in so many ways that they have become almost unrecognizably changed in usage or have even become practically meaningless. The newest names are generally unfamiliar and so present some difficulty as to their meaning and as to where to find information concerning them. A brief glossary of all these names seems therefore to be a desirable convenience if not a necessity.

The fitting of all these faunas into their relative positions in a time scale and the establishment of appropriate conventional divisions of this scale constitute one of the most important aims of mammalian paleontology. The way in which it is done varies greatly from time to time and from individual to individual. This constant change in viewpoint and in knowledge inevitably makes any general correlation tables highly impermanent, but this very impermanence gives value to the attempt. When a subject is in a state of flux, frequent syntheses are all the more requisite if those not directly concerned with the changes are to be informed regarding them and if those occupied in effecting various advances are to remain aware of the nature of the whole problem and of the directions in which it is being modified. No apology is needed for the fact that such a synthesis expresses a personal opinion, if that personal opinion is based on an honest attempt to grasp and coördinate the data of other individual workers on each point involved.

The accompanying glossary contains over one hundred thirty names. About ninety of these are shown on the accompanying map, and about

sixty-five on the correlation charts. The criterion for inclusion in the glossary has been the previous publication of a geographic name applied to a fauna of identified land mammals or to a geologic formation from which such a fauna has been described. Absolute completeness is perhaps unattainable, but it is believed that omissions are few and hoped that

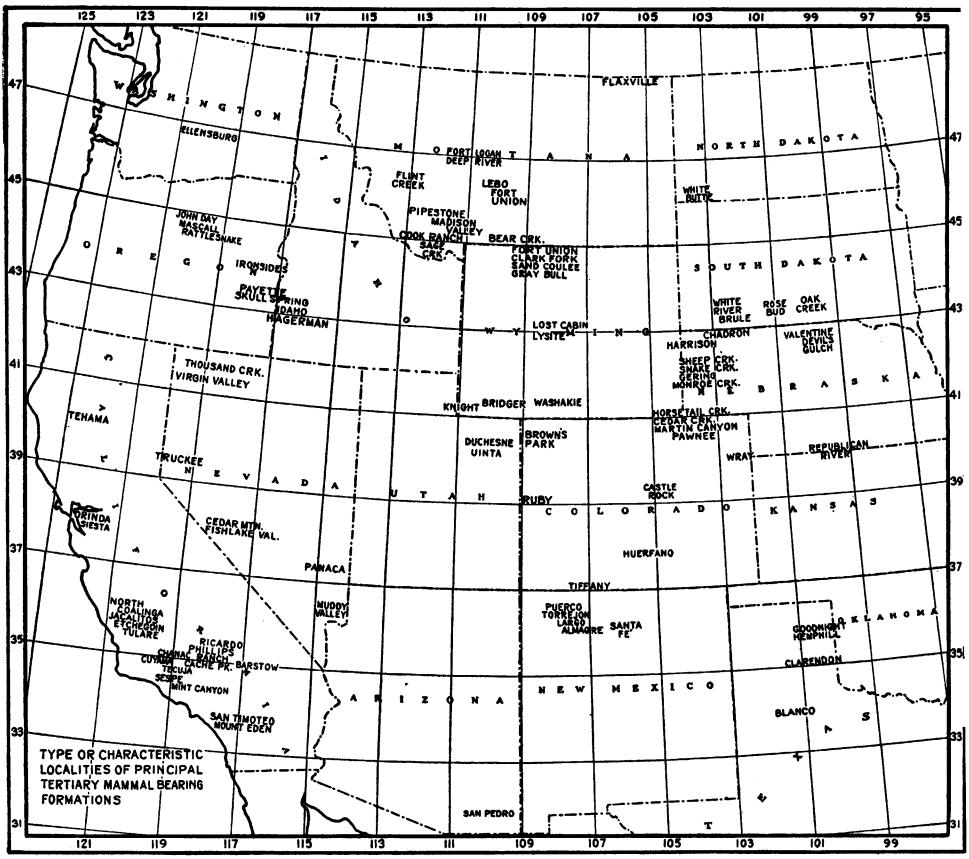

Fig. 1. Map showing the type or most characteristic localities of the principal Tertiary mammal-bearing formations of the West.

they are not important. One or two formations in which a few scraps of mammals are said to occur, without their being really identified in print or of clear significance, are deliberately omitted.

In some cases it is not clear whether an author means a name to designate a fauna or formation or whether he uses it only in a descriptive

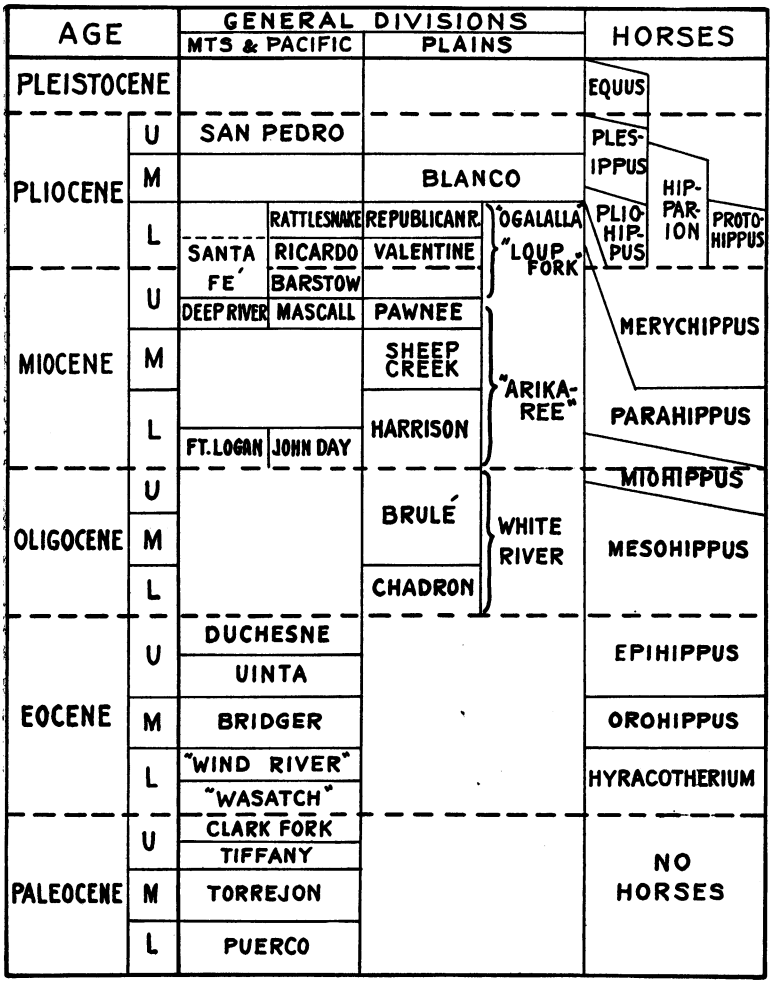

Fig. 2. General correlation table of the American freshwater Tertiary.

The formation names in quotation marks are in current use but are vague or wrongly applied (see glossary). For simplicity, several less common genera of horses are omitted. "*Eohippus*," although now so well known as to be almost vernacular, must be replaced in correct technical usage by *Hyracotherium*.

sense as a pure locality name. Not infrequently a name originally used only geographically comes, without formal proposal, to be applied in a systematic sense to a fauna or formation. Names which have followed this history are included. Some others now known will probably drift into stratigraphic nomenclature in this way as time goes on, but if it is not fairly clear that they have already done so, they are here omitted.

About forty-five of the names in the glossary do not now seem to be correctly or exactly usable for a single mammal-bearing formation. Almost all the rest, the real basis for the stratigraphy of these deposits, are shown on the map. About half of the whole number of names seems to be available for more or less standard comparisons in correlation and is shown on the charts. What is known of the age of the others is given in the glossary.

This paper is not intended to be bibliographic or encyclopedic and the accompanying references are very far from being exhaustive. The names are not traced through the usage of each author employing them. A general idea of the past history and as concise an idea as seems practical and useful of the present common or authoritative usage is given for each. The references are generally to the more recent and comprehensive discussions of correlation and age, and through them the older literature is readily available. The older works, only a few of which are cited, are fully summed up in such general résumés as Osborn and Matthew 1909, Osborn 1910, and Osborn 1918. For the fossils themselves, Hay's well known bibliographies are invaluable and exhaustive, and for the formations the several bibliographies and compendia of the United States Geological Survey are available.

This manuscript was definitely closed on August 15, 1933, and no publications received or seen after that date have been taken into account.

EPOCH BOUNDARIES

Authority for the general sequence of faunas is cited under the individual names in the glossary. Although there are a number of doubtful points, the major features of the sequence are well established and probably will not be seriously questioned on the data now available.

Epoch boundaries and subdivisions, on the other hand, are the subject of wide disagreement. In a general way there is no disagreement that, for instance, the Brulé is Oligocene and the Sheep Creek is Miocene, but there is wide variance as to the exact point where Oligocene ceases and Miocene begins. No two students are in accord as to all these details,

nor does any one student usually remain of the same opinion for very long. It is necessary to draw the lines somewhere and the present arrangement seems to its author and at the moment the most convenient from several different points of view. It is not the only one logically permissible nor is it backed by any burning conviction.

The Paleocene is particularly subject to disagreement, especially among those who are not familiar with the rapidly increasing and as yet

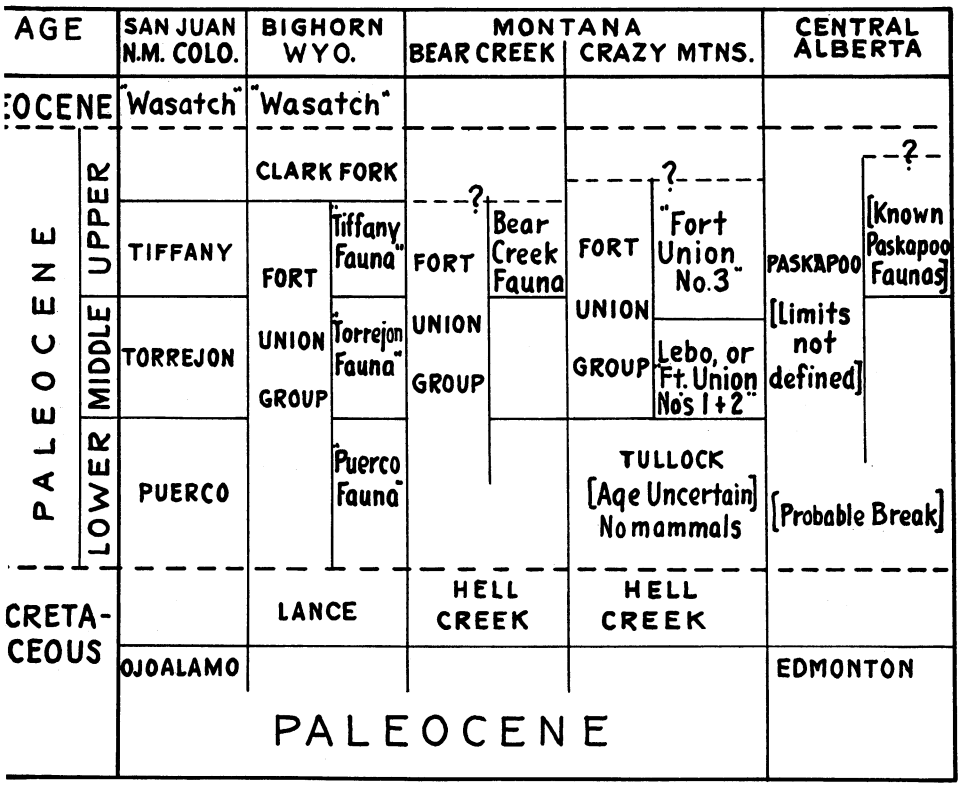

Fig. 3. Correlation chart of the American mammal-bearing Paleocene.

inadequately published data on its mammalian faunas. The name was first applied in Europe and is often still used there in a sense different from that here given it. Whether from a purely stratigraphic or from a paleontological point of view, the American series is much more complete and important, and the definition or redefinition of the name on this basis seems fully justified. Many writers do not recognize the existence

of the Paleocene as a distinct epoch, calling it "Basal Eocene," or even including it in the Lower Eocene. Others, even some recognizing it as a major and distinctive unit, hold that it is not purely Tertiary but belongs in part or altogether to the Cretaceous. There is not space here to discuss this matter, but there are many and very cogent reasons, both faunal and geological, why it fits better in the Tertiary. As to its being a separate epoch, the work particularly of Matthew and Granger and also of several others seems to show that it includes so long and distinctive a sequence of faunas buried in so thick and widespread a series of strata as to be comparable in scope and importance with any of the classic Tertiary epochs.

In the two limited areas where the necessary fossils have been discovered, the exact position of the base of the Paleocene is not in dispute. This line can only be drawn below the Puerco fauna. If the line frequently cannot be drawn in a given rock sequence, this is only because fossils are not known at these questionable localities.

The Torrejon is always included in the Paleocene (under that or any other name), but the more recently discovered and still largely unpublished Tiffany fauna as well as its equivalents and the Clark Fork are sometimes placed in the Lower Eocene. There is a relatively gradual transition, both stratigraphically and faunally, from undoubted Paleocene to undoubted Eocene, as with progressive knowledge there must be between any two epochs. That the Tiffany and Clark Fork rocks were commonly placed in the Eocene before their faunas were known is no argument for retaining them there now, but merely shows that their true relationships were not then known. Drawing the line at the first appearance of "*Eohippus*" (*Hyracotherium*) seems to be the most logical and convenient procedure. In Europe this would place the Sparnacian (often included there in the Paleocene) in the Eocene, and in America would place the Clark Fork (often included here in the Eocene) in the Paleocene.

The Eocene-Oligocene boundary has almost always been placed between the Uinta and the Chadron.[1] When no intermediate faunas were known, this was a very clear-cut division (perhaps the only one in the whole Tertiary), but now several intermediate faunas are known or suspected, and the problem of drawing a sharp line in the midst of a gradual transition again arises. Most definitely known of these intermediate faunas is the Duchesne, placed by its authors, Peterson and Kay,

[1]An exception is Matthew in 1924, but that very useful tabulation contains several surprising and radical features which had not before been suggested by Matthew and were very soon again abandoned by him.

as basal Oligocene. Here, as throughout the Tertiary, the invaluable horse sequence must be of major importance in making faunal divisions, combining this evidence so far as possible with physiographic and stratigraphic changes, with the synchronization of marine deposits, and with correlation with other parts of the world, especially Europe. Very tentatively the Duchesne is here placed at the top of the Eocene. The major physiographic change (from erosion to deposition on the high

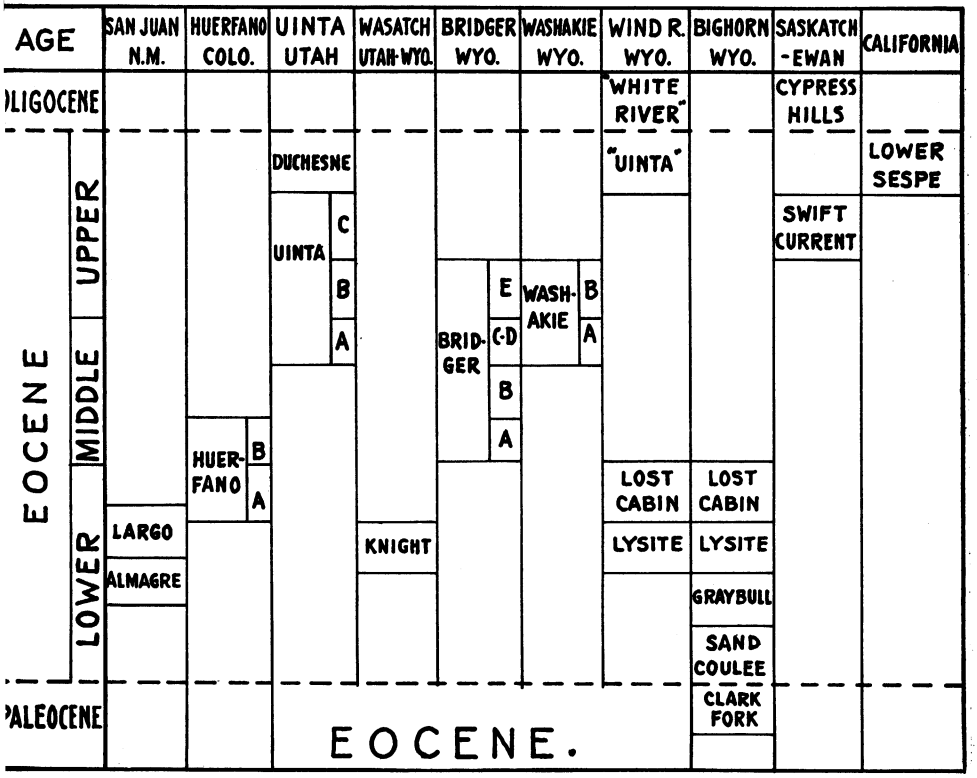

Fig. 4. Correlation chart of the American mammal-bearing Eocene.

plains) was subsequent to the Duchesne. Its horses appear to be somewhat closer to the Uinta *Epihippus* than to the Chadron *Mesohippus*. On this basis, then, the beginning of plains deposition with the Chadron and the appearance in that formation of definite *Mesohippus* define the beginning of the Oligocene.

The Oligocene-Miocene line is more seriously disputed. Almost

everyone would place the Upper Brulé in the Oligocene and the Upper Harrison in the Miocene, but the intervening strata, and especially the John Day, are placed now in one, now in the other. Although it limits the Oligocene to a duration probably shorter than any other Tertiary epoch, it now seems best to draw the line at the top of the classic White River, above the Brulé and below the Harrison (with the Gering and

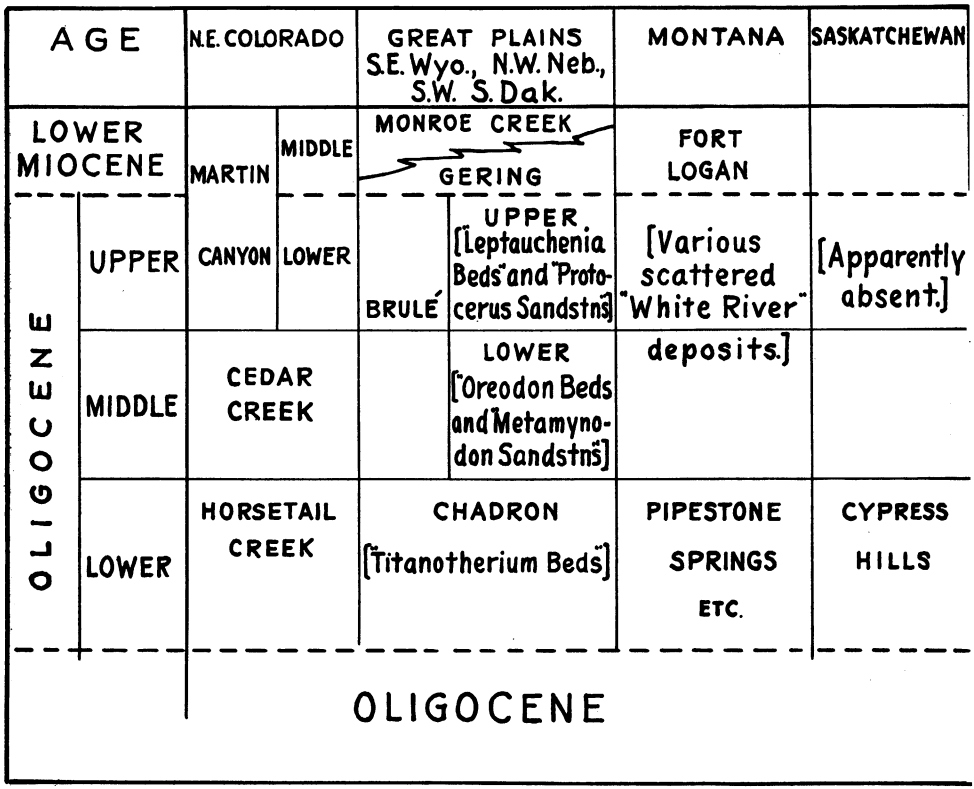

Fig. 5. Correlation chart of the American mammal-bearing Oligocene.

Monroe). This now seems to place most of the John Day in the Miocene, although its relatively barren lower part may overlap the Oligocene. In the plains sequence, at least, there is generally a visible stratigraphic change at this horizon. The beginning of the Miocene then corresponds with the appearance of *Parahippus* or, still more definitely, of *Anchitherium* (with "*Kalobatippus*," or primitive "*Hypohippus*"), which is of

great importance because it appears almost simultaneously in the Old and New Worlds, and is in Europe also generally considered as appearing at the beginning of the Miocene.

But the greatest divergence of all is in the placing of the Miocene-Pliocene line, a divergence between putting formations as early as the Pawnee in the Pliocene and putting those as late as the Thousand Creek

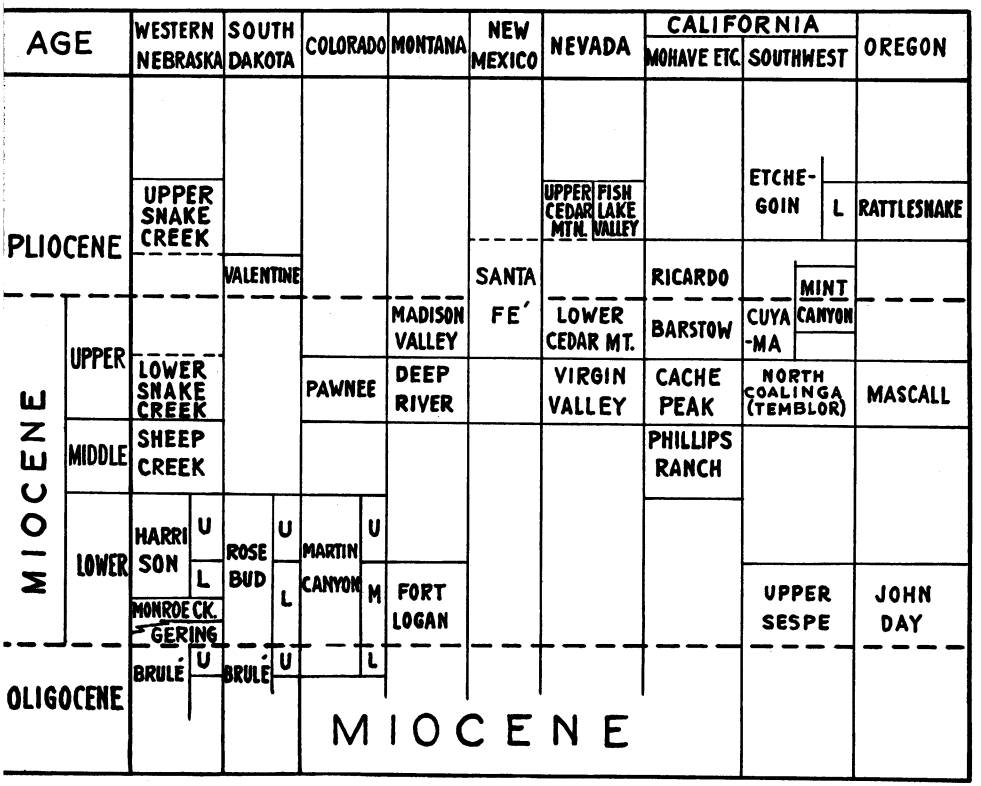

Fig. 6. Correlation chart of the American mammal-bearing Miocene.

in the Miocene. The Europeans, with their Pontian problem, have not been much closer to agreement. The line as here drawn would involve placing the Pontian (or at least the *Hipparion* fauna, commonly called Pontian) in the Pliocene, a defensible even if not universally accepted procedure. It is almost midway between the extreme views of American authors, but is not a compromise but a decision based on positive faunal evidence. If the boundary be placed between the Madison Valley,

Lower Santa Fé, etc., and the Valentine and Ricardo, it coincides with the most definite development of a new "Pliocene" type of horse fauna with *Protohippus*, *Pliohippus*, and *Hipparion* (with various subgenera or very closely allied genera), the latter again furnishing a means for eventual exact correlation with the Old World.

It is only recently that late Pliocene faunas have been recognized in

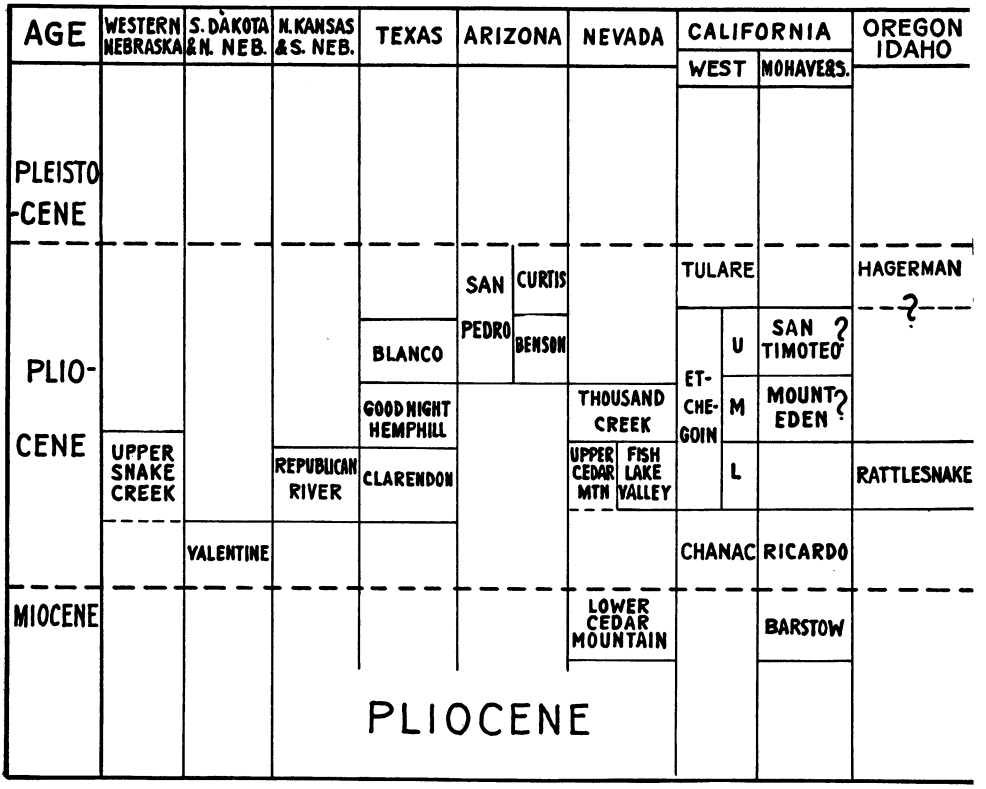

Fig. 7. Correlation chart of the American mammal-bearing Pliocene.

America, and even now they are not well known. Tentatively the Pliocene-Pleistocene line may be placed above the youngest beds containing horses of *Pliohippus-Plesippus* type, that is, above the San Pedro and Idaho. It is possible that by this definition the typically Pleistocene *Equus* appeared before the end of the Pliocene and as the faunas become more clearly known the line may be shifted somewhat. Deposits, such as the Sheridan (or the upper Val d'Arno in Europe), with typical

progressive *Equus* and no other horses are occasionally referred to the Pliocene, but it seems more practical to consider them as early Pleistocene. This definition would also confine the great glacial phenomena to the Pleistocene, which seems to be a more natural arrangement, although some authors, especially in Europe, include the earliest glacial advance in the Pliocene.

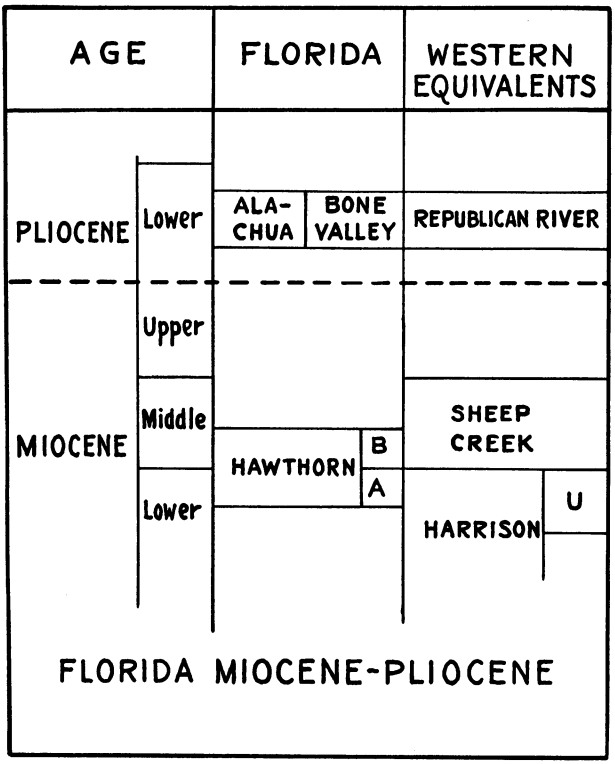

Fig. 8. Correlation chart of the mammal-bearing Tertiary formations of Florida.

GLOSSARY

ALACHUA: The Lower Pliocene "hard rock phosphates" of Florida, largely residual in origin, and associated superficial deposits. Fully discussed by Simpson (1930). The name has been applied to some deposits of different age and origin, and the reported faunas, e.g. of Hay (see references and discussion in Simpson, 1930), often include extraneous species. As restricted, the formation appears to be about equivalent to the Republican River.

ALMAGRE: Lower Eocene of the San Juan Basin, New Mexico. The New Mexico Lower Eocene fauna was described by Cope as a unit, and, before Granger's work, it was called "Wasatch." Granger (1914) demonstrated the presence of two faunal zones, neither of which can properly be called "Wasatch" in either the current or the strictly correct usage. The lower zone was called Almagre, and the upper Largo. Granger considered the Almagre fauna as having characters of both the Lysite and the Gray Bull of the complete Bighorn Basin series. The Sand Coulee equivalent and probably part of the Gray Bull equivalent seem to be missing in New Mexico and represented by an unconformity between Torrejon and Almagre.

ALUM BLUFF: Group name under which have been included the Florida fossil horizons now placed in the Hawthorn, which see. Simpson 1930.

ARIKAREE: Obsolescent term for part of the Miocene (usually Lower Miocene) of the central plains area. The name proposed by Darton (summed up in Darton 1905A) for the "principal component of the series termed 'Loup Fork'" between the Brulé and the Ogalalla, with the Gering at or in its base. Hatcher (1902) divided the Arikaree into Monroe Creek and Harrison (but excluded the Harrison on a later page), and confined the term "Loup Fork" to higher horizons. Matthew (1907) stated that the "Arikaree" is Middle or Late Miocene in northeastern Colorado, Lower Miocene and perhaps in part Oligocene south of White River in South Dakota, and for the most part of unknown age. He proposed the use of the term only in a broad way and the giving of more exact local names to specific formations. Because of this ambiguity, the name is now infrequently used by paleontologists.

BARSTOW: Upper Miocene of the Mohave Desert, California. At first calling it the Mohave Fauna, Merriam (1915A) later more explicitly defined it as the Barstow fauna, and finally (1919) discussed its fauna and stratigraphy in detail. He placed it as Upper Miocene, older than the Ricardo, younger than Mascall and Virgin Valley, about equivalent to the Cedar Mountain (i.e., Lower Cedar Mountain of present usage), and at least in part to the Santa Fé. Very extensive work has subsequently been done on this formation (Frick), but the stratigraphic or correlative results are not yet available.

BEAR BUTTE: A name sometimes used descriptively for the fauna found by Douglass in the Fort Union of the Crazy Mountain field. See "Fort Union." The name is not formally established for a faunal or stratigraphic unit.

BEAR CREEK: Name applied to an Upper Paleocene fauna from the Fort Union group of Bear Creek in southern Montana. Fauna described by Simpson (1929) and correlated with the Tiffany. See also Fort Union.

BENSON: See San Pedro.

BIG HORN: Used by Osborn (1929) for the entire series of the Bighorn Basin, including Clark Fork, Sand Coulee, Gray Bull, Lysite, and Lost Cabin, but not in general use as a stratigraphic or faunal name. See Wasatch.

BLANCO: Middle Pliocene of the Texas Panhandle. First studied by Cummins and by Cope, more carefully delimited by Gidley (1903) who placed it in the Pliocene. Osborn and Matthew (1909) considered the Blanco as Middle Pliocene, and this has since been the common usage, although by some it is considered Upper Pliocene (without questioning its position in the general sequence). Much collecting has been done in recent years, but the fauna has not again been revised or its correlation yet discussed on the basis of the new discoveries. The fauna is clearly considerably later than the Clarendon or Goodnight of the Panhandle, yet is surely pre-Pleistocene.

BONE VALLEY: Also called "land pebble phosphate" or "pebble phosphates." A Lower Pliocene estuarine formation of Florida with numerous land mammals. Fully discussed by Simpson (1930). Nearly or quite contemporaneous with the Alachua of the same state, and approximately of Republican River age.

BRIDGER: Middle Eocene of the Bridger Basin, southwestern Wyoming. The formation was first explored by Hayden, and early fossil collections described by Leidy, Cope, and Marsh. The paleontological literature is very large. Early stratigraphic work was summed up and definitively supplanted by that of Matthew and Granger (Matthew 1909). For exact field recording, they divided the whole formation into five major zones, A, B, C, D, and E, and each zone or stage into five numbered levels, A_1, A_2, etc. These actual horizon divisions for field records do not correspond to major faunal divisions. Horizon A contains very few fossils and was not correlated by Matthew. Bridger B, one of the richest formations of the entire Tertiary, contains essentially a unit fauna quite distinctive, and not of the exact age of any other known American fauna, unless the newly discovered "Bridger" of the Sand Wash Basin, Colorado, proves to belong here (Abel and Cook 1925). C and D are not distinctly separable faunally and together constitute a distinctive, very rich, faunal horizon (of the same age as Washakie A). E contains no identifiable fossils. Bridger B is the Lower Bridger of

various authors and C–D the Upper Bridger. Osborn (1919) later distinguished Bridger A faunally and correlated it with Huerfano B.

BROWN'S PARK: Middle or Upper Miocene of northwestern Colorado. Fossils were found and described from these beds by Peterson (1928). He considered them as of Upper Miocene or transitional Middle to Upper Miocene age. They are perhaps about equivalent to the Deep River. The lower part of the formation was named the "Weller horizon," including the fossiliferous "Weller sandstone" at its summit. The Uinta Basin beds at first placed here are much older and were subsequently defined as Duchesne, which see.

BRULÉ OR BRULE: Middle and Upper Oligocene of the western plains. Name applied by Darton (see especially 1905A) to the Middle and upper divisions of the typical White River. Lower Brulé is the same as Middle White River or "*Oreodon* clays and *Metamynodon* sandstones." Upper Brulé is the Upper White River or "*Leptauchenia* clays and *Protoceras* sandstones." See White River.

CACHE PEAK: Middle or Upper Miocene of the southern Sierra Nevada, California. Buwalda (1916) described the upper fauna of the Monolith Series under this name, and placed it between Phillip's Ranch and Barstow, nearer the latter. Merriam, and Osborn (1918) correlate it with the Pawnee.

CASTLE ROCK: Lower Oligocene of central Colorado (south of Denver). Darton (1905B) reported the discovery of *Titanotherium* in the upper part of the Monument Creek formation of this region and its consequent Lower Oligocene age. Richardson (1912) applied the name "Castle Rock Conglomerate" to this upper member of the "Monument Creek group."

CEDAR CREEK: Middle Oligocene of northeastern Colorado. Named and discussed by Matthew (1901). The rich and beautifully preserved fauna seems to be exactly that of the Middle White River, Lower Brulé, or "Oreodon Beds."

CEDAR MOUNTAIN: Later Tertiary of southwestern Nevada. Fauna discussed by Merriam (1916A) who compared it with the Barstow and Santa Fé.

Stirton (1932) has divided the fauna into two very distinct parts, one said to be of Middle Miocene age (but apparently close to the Santa Fé, here considered Upper Miocene and transitional to Pliocene) and the other (rather scanty) Lower Pliocene, compared (indirectly) by Stirton with Upper Snake Creek, Valentine, and Little White River.

CHADRON: Lower Oligocene of the western plains. This name was

given by Darton (see especially Darton 1905A) to the lower member of the White River group and is synonymous with Lower White River or "*Titanotherium* Beds" in this area. See White River.

CHANAC: Late Tertiary of the Tejon Hills near the southern end of the Great Valley of California. Vertebrates from this region were at first supposed to be from marine beds, but were later (Merriam 1916B, 1917) found to be from a distinct higher formation of terrestrial origin, named Chanac by Buwalda. The very scanty fauna is believed by Merriam to be closest to the Ricardo, i.e., basal Pliocene of the present correlation charts.

CLARENDON: Lower Pliocene of the Panhandle, Texas. Named and discussed by Gidley (1903) who placed it in the Upper Miocene or "Loup Fork," and included in it the Goodnight. Matthew and Stirton (1930B) have most recently mentioned this formation, showing that it is slightly older than the Goodnight and about equivalent to the Republican River, hence referable to the Lower Pliocene of the present and most other correlations.

CLARK FORK: Uppermost Paleocene of the Bighorn (or Clark Fork) Basin, northern Wyoming. Sinclair and Granger (1912) found and first discussed this fauna. They named the beds "Ralston" and considered them as possibly partly equivalent to the Knight or possibly uppermost Fort Union. Granger (1914) changed the name to Clark Fork ("Ralston" having been used previously for a Pennsylvanian formation in Oklahoma), and stated that the Knight is considerably more recent (=Lysite) in age. Granger considered the beds as stratigraphically the base of the Lower Eocene series, but as faunally nearer to the Paleocene (Torrejon). Jepsen (1930) added to the known fauna and discussed the stratigraphy. He concluded that the Clark Fork and Gray Bull are closely related and continuous, indeed that the whole Paleocene-Lower Eocene of the Bighorn region is essentially continuous. In the absence of any sharp stratigraphic or faunal break, it is now customary and convenient to draw the line between Clark Fork and Sand Coulee or Gray Bull.

COOK RANCH: Middle Oligocene of southwestern Montana. This name is applied by A. E. Wood (1933), referring to an unpublished manuscript by H. E. Wood, to beds in the Sage Creek region, younger than the Sage Creek Beds, from which a small fauna of Middle Oligocene (Lower Brulé) mammals was obtained.

CURTIS: See San Pedro.

CUYAMA: Late Tertiary of Ventura County, California. Fauna described by Gazin (1930), who correlates it with the Barstow (Upper Miocene).

CYPRESS HILLS: Lower Oligocene of Saskatchewan. The fauna was first described by Cope, and was revised by Lambe (1908). A new revision by Russell is in preparation. The beds to which the name Cypress Hills is to be confined are of Chadron age. An older fauna has recently been discovered in the same general region and series of rocks, see Swift Current.

DEEP RIVER: Middle or Upper Miocene of central Montana. Fossils from these beds were first described by Cope, and Scott (1894B) revised the fauna. He named the beds Deep River, from the name Deep Creek once applied to the Smith River, in the valley of which the beds occur. Two distinct faunas were recognized, a lower, possibly of John Day age, and an upper, since shown to be approximately equivalent to the Pawnee, Virgin Valley, and Mascall. Douglass (1899) called the beds "Smith or Deep River," and later (1903) confined the name "Deep River" to the upper horizon, from which came all of Cope's material, and called the lower beds "Fort Logan." Some collecting has since been done in the Fort Logan and Deep River, but the fauna has not been recently revised.

DEVIL'S GULCH: Miocene-Pliocene of Niobrara River, Nebraska (near Ainsworth). Mammals from these beds were described by Barbour (1914) and several other individual forms have been published. Barbour and Cook (1917) gave a faunal list and placed the Devil's Gulch above the Snake Creek. Osborn (1918, in part quoting Matthew) pointed out that two faunas occur, a lower level of the "*Procamelus* zone" (about Valentine?) and an upper level perhaps somewhat younger than the Snake Creek. The available faunal list suggests an even longer span, probably at least Middle Miocene well into Pliocene. Much work has recently been done in this general region but the stratigraphic results are not yet available.

DUCHESNE: Transitional Eocene-Oligocene of the Uinta Basin, northeastern Utah. Before fossils were found in these beds, they were generally in part or wholly included in Uinta C as an unfossiliferous superior part. Peterson (1928) restricted Uinta C to the classic upper fossil beds whence came the so-called "true Uinta" fauna of early collectors. At that time he called this upper series "Brown's Park," correlating it with the true Brown's Park of adjacent Colorado. Later more determinable fossils were found, and Peterson and Kay (1931) recognized the series as much older than the Brown's Park and called it "Upper Uinta." As this name is commonly and more properly applied to the classic Uinta C or C_1 fauna, Peterson (1931) soon proposed the

name Duchesne. The fauna was considered as intermediate between Uinta C_1 and Chadron, and placed at the base of the Oligocene. A position at the top of the Eocene is equally defensible, as the faunas are continuous, there appears to be no unconformity, and the Duchesne is older than the major change in sedimentation from mountain basins to the plains. Probably several faunas hitherto correlated with Uinta or Chadron should be placed in this newly recognized intermediate zone. Peterson and Kay (1931) suggest that the Beaver Divide "Uinta" may be intermediate between Uinta C and Duchesne, and Peterson (1931) adds that the Sage Creek Beds (which see) may belong between Duchesne and Chadron. The recently discovered Lower Sespe (see Sespe) fauna may be of Duchesne age.

The probable existence of the Duchesne fauna was anticipated by Osborn (e.g. 1929) on theoretical grounds, as he placed the then unknown fauna of "Uinta C_2" in a missing life zone.

DUNNELLON: A Pliocene Florida formation named by Sellards in 1910. In 1914 Sellards concluded that this formation is inseparable from the Alachua and dropped the name Dunnellon. See Simpson 1930. See Alachua.

EDEN: See Mount Eden.

EDSON: Lower Pliocene, Sherman Co., Kansas. Used geographically by Martin and by Matthew and Stirton (1930A), then given stratigraphic status as "Edson Beds" by Stirton and Vander Hoof (1933). About equivalent to the Hemphill.

ELLENSBURG: Pliocene of Washington. Merriam (1916) reports a flora possibly of Mascall age in the lower part, and an upper horizon, probably Lower Pliocene, with *Hipparion.*

ESMERALDA: Widespread later Tertiary (Miocene-Pliocene) deposit of Nevada. The name has been rather loosely applied for various deposits of this approximate age. Scattered mammals have been found, but only the Cedar Mountain and Fish Lake Valley faunas (which see) are fairly adequate and well known.

ETCHEGOIN: Pliocene of the western border of the San Joaquin Valley, California. Merriam (1915B, 1917) lists three zones, placing the upper (*Pliohippus proversus*) at or slightly before the Blanco, the middle (*Pliohippus coalingensis*) with the Thousand Creek and Rattlesnake, and the Lower (*?Hipparion*) (together with the Chanac) with the Ricardo and after the Republican River. [The Republican River now appears to be slightly later than the Ricardo, and may more nearly correspond with this very poorly known Lower Etchegoin.]

FISH CREEK: Name, of no definite standing, sometimes applied to the Fort Union faunas of the Crazy Mountain Field. See Fort Union.

FISH LAKE VALLEY: Late Tertiary formation of southwestern Nevada. Occurs near the Cedar Mountain, and its fauna apparently is equivalent to (but considerably richer than) the Upper Cedar Mountain. Stirton (1932) has listed the fauna, which he compares with the Upper Snake Creek, Valentine, and Little White River.

FLAXVILLE: Early Pliocene of northwestern Montana. The Flaxville gravels were named by Collier and Thom (1918) and Gidley reported (in their paper) on the fragmentary mammals. He considered them Upper Miocene, but this depends on drawing the Mio-Pliocene line higher than is here done, and the fauna is, by present standards, predominantly Lower Pliocene, with a possibility that transitional Miocene horizons are present.

FLINT CREEK: Upper Miocene of western Montana. Douglass, who discovered and described the fauna, has given a faunal list (1903). The beds appear to be of nearly the same age as the Madison Valley. Douglass was inclined to place them between Deep River and Madison Valley.

FORT LOGAN: Basal Miocene of central Montana. Scott (1894) and Douglass (1899) separated the Deep River into upper and lower parts. Douglass (1903) gave the name Fort Logan to the lower fauna. Scott correlated the Fort Logan with the John Day, and this was provisionally accepted by Douglass.

FORT NIOBRARA: See Valentine.

FORT UNION: A group of Paleocene formations of the northern high plains. The name was first proposed by Meek and Hayden, after Fort Union (now Buford) in North Dakota. It has been very widely applied to the frequently lignite-bearing terrestrial series so widespread in North Dakota, South Dakota, Montana, and Wyoming, overlying the dinosaur-bearing Lance or Hell Creek and (in places) underlying the true Eocene "Wasatch." In the absence of fossils, local subdivision and widespread correlation are very difficult and it is evident that the boundaries of the supposed "Fort Union" as used by different authors are widely at variance, including part or all of what Paleocene may be present, also often true Cretaceous or true Eocene (e.g., Wegemann 1917). There is a very large literature on the Fort Union in general, mostly summed up by Thom and Dobbin (1924). Thom and Dobbin divided the Fort Union into Lebo, lower, and Tongue River, upper, members, excluding the Tullock below and the Sentinel Butte above, both the

latter (or their equivalents) having clearly been included in the Fort Union by various other authors. It seems clear that these lithologic divisions do not exactly correspond to the known faunal distinctions and also highly probable that any one is not really synchronous over the whole area. Isolated and fragmentary fossils have been found at several scattered localities. For the most part they indicate Torrejon, and perhaps also Tiffany or Clark Fork, age. Three areas have yielded adequate mammalian faunas: The Crazy Mountain Field, Bear Creek, and the Bighorn Basin.

Mammals were first discovered near the Crazy Mountains, central Montana, by Douglass (1902, 1908), who correlated the forms found by him with the Torrejon. A very rich collection was subsequently made by Silberling and Gidley. Gidley (see 1923) described a few of these mammals, confirming the approximate correlation of the principal fauna with the Torrejon. The stratigraphy, in its relation to the mammalian faunas, has not been given in any detail. It is hoped to do this in the near future in a memoir by the present writer. It is highly probable that two or more distinct faunal zones are present, the lowest and far the richest of about Torrejon age. The whole Lebo of Stone and Calvert and some other authors in this, the type, locality is apparently of Torrejon age. It is lithologically divisible into two members, "Fort Union No. 1" and "No. 2." of Silberling. The overlying "Fort Union No. 3" is apparently also of Torrejon age at the base, and probably ranges up into the latest Paleocene above.

The Bear Creek fauna of southern Montana, described by Simpson (1929), is an isolated microfauna from a single horizon, of Tiffany age.

In the Bighorn Basin (or Clark Fork Basin) of northern Wyoming, Jepsen (1930) found a sequence of fragmentary but characteristic faunas in the Fort Union. These indicate three faunal zones; the lower, in beds hitherto considered Lance but apparently unconformable on the true Lance, seems to be of Puerco age; above this is a Torrejon fauna, and, still higher, one tentatively correlated with the Tiffany and Bear Creek. Above these is the Clark Fork of Granger. Jepsen did not apply local faunal or stratigraphic names to these several zones below the Clark Fork.

GERING: Lower Miocene of western Nebraska. The name was proposed by Darton (see 1905A) for sandstones unconformable on the Brulé. He considered the Gering only as a channel facies at the base of his Arikaree. Peterson (1906) showed the beds as continuous with the overlying Monroe Creek, and so did Cook (1915). The name as used

apparently applies not to any separate faunal zone or geologic formation but only to a sandy facies at the base of various Miocene formations. The scanty fauna is of transitional Oligocene-Miocene type.

GOODNIGHT: Pliocene of the Texas Panhandle. This name was first applied by Cummins to beds from which Cope described three species of horses. Gidley (1903) denied their distinction from the Clarendon. Matthew and Stirton (see especially 1930B), however, have now partly described a fauna from Hemphill County which appears to be distinct from the apparently older Clarendon and equivalent to the Goodnight. This is accordingly designated as the Goodnight, Goodnight-Hemphill, or Hemphill fauna, and the Lower Pliocene of Texas is divided into two immediately successive but separable faunas, Clarendon and Goodnight-Hemphill. Both are distinctly older than the Blanco. The type locality of the Goodnight is west of Clarendon, and the Hemphill is separate, some distance north. See Hemphill.

GRAY BULL: The typical Lower Eocene of the Bighorn Basin, northern Wyoming. It is to the very rich and abundant fauna of this formation that knowledge of Lower Eocene life in America is chiefly due. The literature is very extensive, and the fauna has been described in great detail, and revised by Matthew and Granger. Previous to 1914 the beds were generally called "Wasatch." Sinclair and Granger (1911, 1912) correlated them with the Knight of the Wasatch Basin. Granger (1914) later showed that the true Knight is of later (Lysite) age, and accordingly proposed the name Gray Bull for these beds in the Bighorn Basin. No fossiliferous beds of exactly this age are known elsewhere, although the Almagre probably partly overlaps it in age. The name is synonymous with "Wasatch" as used (but incorrectly) in most paleontological literature. See Wasatch.

HAGERMAN: Late Pliocene of Twin Falls County, Idaho. The name "Hagerman lake beds" is used by Gazin (1933) in referring to a lake series in the vicinity of Hagerman generally considered as part of the Idaho formation. As the name "Idaho" (which see) has been used very vaguely for widespread beds probably of several different ages, the more local name will probably be accepted for this important, more limited series. Its fauna, still inadequately described, is evidently Upper Pliocene, and perhaps very latest Pliocene.

HARRISON: Lower Miocene of western Nebraska. This part of the "Arikaree" of Darton was given the local name Harrison by Hatcher (1902), also studied by Peterson (1906) and Cook (1915). The fauna is extraordinarily rich and is described by many authors, but a really com-

plete review and stratigraphic study has not yet been made. Hatcher considered it to fill the time gap between Lower and Upper Deep River, i.e., between Fort Logan and Deep River. Later discoveries indicate that it does this in part, but that the Lower Harrison is little if any later than the Fort Logan. Lower Harrison (with or including the Monroe Creek) seems to correspond closely with the Lower Rosebud, Fort Logan, and part of the John Day, and Upper Harrison with Upper Rosebud, distinctly earlier than the overlying Sheep Creek. The division now recognized as Upper Harrison was at first confused by Hatcher and Peterson with the much later "Nebraska."

HAWTHORN: Miocene marine and estuarine formation in Florida containing, with its equivalents, many land mammals. Fauna and correlation fully discussed by Simpson (1930, 1932). Faunas tentatively divided by Simpson into earlier and later, lettered respectively A and B, and considered transitional from Lower Miocene (Upper Harrison) to Middle Miocene (Lower Sheep Creek).

HEMPHILL: Lower Pliocene, Hemphill County, Texas. The fauna, partly described by Matthew and Stirton (1930B, etc.), seems to be late Lower Pliocene, between Clarendon and Blanco. Reed and Longnecker (1932) formally proposed the name "Hemphill beds" and described them in great detail. See Goodnight.

HORSETAIL CREEK: Lower Oligocene of northeastern Colorado. Named and correlated by Matthew (1901). The fauna is scanty but appears to be the exact equivalent of the Lower White River, Chadron, or "*Titanotherium* Beds."

HUERFANO: Lower and Middle Eocene of the Huerfano Basin, southeastern Colorado. Hills first described the beds and found a few fossils. Osborn (1897) and Wortman later explored the formation, and divided it into two faunal levels, later called Huerfano A and B. According to these studies, and field work by Granger in 1918 (summed up and interpreted in Osborn, 1919), Huerfano A is of about Lost Cabin (Upper Wind River) age, and Huerfano B predominantly of Bridger A age, but the two when better known will probably prove to be continuous and with a full transition between these two zones. The great bulk of the formation has few or no fossils and lies below the characteristic Huerfano B.

IDAHO: Under this name has been included a large series of rocks in Oregon and Idaho, probably covering a long span of time. Even with the omission of the "Ironside" of Merriam from which there are a few scraps of Lower Pliocene aspect, the faunas may range through the latter half of

the Pliocene and into the Pleistocene. See Merriam 1917. Recently (Gidley 1930, 1931) a very fine series of *Plesippus* has been found in the Idaho of the State of Idaho. Still more recently, Gazin (1933) has reported the discovery of a more varied fauna in the same beds as Gidley's *Plesippus*. Gazin calls this particular series the "Hagerman lake beds." This fauna is evidently late Pliocene, but has not yet been described as a whole.

IRONSIDE: A locality and, tentatively, a faunal name for a very poorly known fauna in beds commonly referred to the Idaho Formation but manifestly older than the better known faunas of that formation. See Merriam 1917. At Ironside, Oregon, a *Hipparion* was found, and from localities in Idaho *Teleoceras*, *Protohippus*, etc., have been reported, indicating a probable Lower Pliocene age, whereas the more characteristic Idaho faunas are clearly uppermost Pliocene or even in part Pleistocene. See also Payette.

JACALITOS: Lower Pliocene of the North Coalinga Region, California. Merriam (1915B) reported a very scanty fauna which he placed in the Lower Pliocene.

JOHN DAY: Upper Oligocene and, or, Lower Miocene of the John Day Basin, Oregon. Since their discovery by Condon, these beds have been repeatedly and intensively worked and the faunas and stratigraphy studied by Leidy, Cope, Marsh, Merriam, and many others. Marsh's name John Day has become universally accepted, although it has also been called Truckee and Oregon. Merriam (1901) first thoroughly reviewed the formation and its fossils. He divided it into Lower, Middle, and Upper John Day. The lower is almost barren, the middle is the "*Diceratherium* beds" of Wortman, the upper the "*Merycochoerus*," "*Paracotylops*," or "*Promerycochoerus* beds." Earlier opinions as to age varied widely but by 1906 (see Merriam 1906) it was held that the beds are post-White River but probably not far removed, much earlier than the "Loup Fork." Merriam and Sinclair (1907) referred the John Day mainly to the Oligocene, with Upper John Day perhaps overlapping in part into the Lower Miocene. Osborn and Matthew (1909) placed it as Oligocene and transitional to Miocene, the Middle John Day not paralleled exactly (later than Brulé) and the Upper perhaps of Lower Rosebud age. This approximate relative position is not seriously questioned, although there is still no general agreement as to whether the Eocene-Oligocene line belongs below, within, or above the series. Matthew (1924B) later held that there is little to separate the two John Day faunas and that Middle and Upper John Day may both be classed with Lower Rosebud.

KNIGHT: The fossiliferous Lower Eocene of the Wasatch Basin, Wyoming. Veatch (1907) divided Hayden's type Wasatch into the Almy, Fowkes, and Knight. Fossils are found only in the Knight, the uppermost division, and are there scarce and fragmentary. Sinclair and Granger (1911, 1912), accepting the then universal correlation of the pre-Wind River Eocene beds of the Bighorn Basin with the fossiliferous type Wasatch, also used the name "Knight" for these Bighorn deposits. Later Granger (1914) found this incorrect, rejected the use of the name "Knight" for any Bighorn formation, and correlated the typical Knight with the Lower Wind River or Lysite. See Wasatch.

LARGO: Upper division of the Lower Eocene of the San Juan Basin, New Mexico. Cope described the fauna of the New Mexican "Wasatch" as a unit. Granger (1914) held that there are found two successive faunal phases and that the name "Wasatch" is not properly applicable to either, or to both. He therefore named the upper division Largo and the lower Almagre. He correlates the Largo principally with the Lost Cabin, but tabulates it as transitional Lysite-Lost Cabin.

LEBO: A member of the Fort Union group which, near its type locality in the Crazy Mountain Field, contains a rich fauna of Torrejon age. See Fort Union.

LITTLE WHITE RIVER: See Valentine.

LOST CABIN: Late Lower Eocene formation of the Wind River and Bighorn Basins, Wyoming. Sinclair and Granger (1911) found that the beds of equivalent age in these two basins contained two distinct faunas and therefore divided them into the Lysite (below) and Lost Cabin (above), using both names in both basins. The classic term Wind River was retained as a group name for both Lysite and Lost Cabin. In fact the Wind River specimens of previous workers all came from the upper beds, hence the Lost Cabin fauna of Sinclair and Granger is the same as the Wind River fauna of previous authors. See also Lysite, Wind River. The fauna has been largely revised by Matthew and Granger.

LOUP RIVER, LOUP FORK: Obsolete terms once in general use for part or all of the Miocene. The history of these unfortunate names is summed up by Osborn and Matthew (1909). The "Loup River" was defined by Meek and Hayden in Nebraska as a formation, in largest part palpably of Pleistocene age, but also made to include all the adjacent deposits down to the White River. Leidy continued to confuse the true or type "Loup River," Pleistocene, with the much older Upper Miocene or Lower Pliocene ("Nebraska"). From this the name was generalized by Cope, in the form "Loup Fork" as an epoch name in which he placed

the Santa Fé. The name continued for a time in general use and the most diverse horizons were referred to it, from what is now considered Lower Miocene to the Lower Pliocene. It has no historic authenticity, unless "Loup River" be retained for a Pleistocene horizon, and no accurate and exact meaning, so that it has necessarily been discarded for the most part, although occasionally employed for the Nebraska or Valentine stage.

LYSITE: A Lower Eocene formation of the Wind River and Bighorn Basins, Wyoming. Sinclair and Granger (1911) showed that the beds of the Wind River Basin and those of the same age in the Bighorn Basin contain two readily distinguished successive faunas. They therefore proposed the name Lysite for the lower part of this series, retaining the name "Wind River" for the group as a whole. The Lysite is thus the lower part of the Wind River Group. It is, however, older than the Wind River faunas of authors previous to 1911. See Lost Cabin and Wind River. The fauna has been in large part reviewed by Matthew and Granger.

MADISON VALLEY: Upper Miocene of southwestern Montana. Douglass (1899) first recorded this fauna as from the "Loup Fork," subsequently (1903) using the name "Madison Valley Beds," as a local series of "Loup Fork" age. It appears to be of latest Miocene, about lower Santa Fé, age.

MARTIN CANYON: Transitional Oligocene–Miocene of northeastern Colorado. As first named and discussed by Matthew (1901) it was evident that much of the fauna was of Upper Oligocene (Upper White River, Upper Brulé) age, but that a scanty representation of one or more later faunas was present. It was subsequently recognized (e.g., Osborn and Matthew 1909) that the whole Lower Miocene, including equivalents of Upper Harrison and Upper Rosebud, is also included in the Martin Canyon Formation.

MASCALL: Middle or Upper Miocene of the John Day Basin, Oregon. The formation has long been known, in earlier literature called "Loup Fork," "Cottonwood" (a local but preoccupied name), and by various faunal names. Merriam (1901) proposed the name Mascall, and pointed out that it is much younger than the John Day. In 1906, Merriam placed the Mascall not far from the Deep River. Merriam and Sinclair (1907) reaffirmed correlation with Deep River and Pawnee, Middle or Upper Miocene, and this has since been generally accepted.

MINT CANYON: Later Tertiary Formation of Los Angeles County, California. Varied but fragmentary fauna described by Maxson (1930) seems to indicate an age near to or slightly later than the Barstow.

MOHAVE: Geographic designation for the fauna of the Barstow syncline, Mohave Desert, used by Merriam but later abandoned in favor of the more explicit name Barstow. See Merriam 1919.

MONOLITH: Miocene of the southern Sierra Nevada, California. Two faunas occur at different levels: see Cache Peak and Phillips Ranch.

MONROE CREEK: Lower Miocene of western Nebraska. The name was applied by Hatcher (1902) to beds between the Gering and Harrison, conformable with both. The formation was also so shown by Peterson (1906) but Cook (1915) showed it as unconformable under the Harrison. The scanty fauna (e.g., Osborn and Matthew 1909) is not significantly older than Lower Harrison and is at least partly equivalent to the Lower Rosebud. The real relationships of the formation do not yet seem clear, and it, like the Gering, is very possibly only a local facies synchronous with beds elsewhere placed in the Harrison or Rosebud.

MONUMENT CREEK: See Castle Rock.

MOUNT EDEN: Lower or Middle Pliocene of southern California. Named Eden by Frick (1921) who correlated it with Middle Etchegoin, Rattlesnake and Thousand Creek. Much later work by Frick has not yet been published in detail, but in his recent description of some of the Eden mastodonts (Frick, 1933) he gives a faunal list (p. 516) and calls the formation Uppermost Pliocene. The fauna seems, however, to be of older aspect than those here defined as Uppermost Pliocene (e.g., the Idaho). Fraser gave the name Mount Eden, "Eden" being preoccupied by an eastern Paleozoic formation.

MUDDY VALLEY: Miocene (?) of southeastern Nevada. Named by Stock (1921B) who described a very fragmentary fauna and doubtfully placed it in the Miocene.

NACIMIENTO: Group name for Puerco and Torrejon, not in current paleontological use. See Puerco.

NEBRASKA: Proposed by Scott (1894A) for deposits of western Nebraska apparently synchronous with those now called Valentine (which see). Hatcher (1902) and Peterson (1906) applied the name to much older beds now included in the Upper Harrison. The name is not in current use in either sense. ("Nebraskan" is a stage of the Pleistocene.)

NIOBRARA RIVER: See Valentine.

NORTH COALINGA: Miocene fauna of Kings County, southern California. From the North Coalinga region, Merriam (1915B) described three faunas or groups of faunas, from the "Temblor" or "Vaqueros," from the Jacalitos, and from the Etchegoin. In some subsequent

references the oldest fauna, characterized by *Merychippus*, is descriptively referred to as that of North Coalinga, and this designation may be used tentatively. Merriam states that the mammal zone is included in the "Temblor" or "Vaqueros" of various authors and is part of the Monterey series, but usage is confused and the marine correlations uncertain. Merriam considered the scanty fauna as Miocene and at least as advanced as Mascall and Virgin Valley.

OAK CREEK: Lower Pliocene of South Dakota. The beds were named and a small fauna described by Troxell (1916). He considered the fauna as corresponding to the Snake Creek, i.e. (as then believed), somewhat more modernized than the Republican River. Osborn (1918) placed it earlier, before the Republican River and equivalent to the Valentine.

OAKVILLE: Terrestrial Miocene intercalated in the marine series of the western Texas coastal plain. Fragmentary fossils from various horizons and localities, said to be in this formation (especially as reported in Deussen 1924), suggest Miocene, probably Middle Miocene, age, without excluding the possibility that they may range as late as earliest Pliocene.

OGALALLA: General name for later Tertiary of the central Great Plains, for the most part of Lower Pliocene age. The name was applied and used by Darton (especially 1905A) for the widespread sandstones which unconformably overlie and extensively overlap his "Arikaree." The latter is chiefly composed of Miocene deposits (especially Lower but also Upper Miocene) and the Ogalalla is defined to include part or all of the many later Miocene and, especially, Lower Pliocene beds and facies of the same region. It clearly includes the two horizons now generally called Valentine and Republican River, as well as numerous other minor horizons and local formations. As a stage name it has been widely used (e.g., in Osborn and Matthew 1909), where it includes formations now placed in both Miocene and Pliocene in three stages, Barstow, Valentine, and Republican River. In this sense it is nearly the same in usage as the even more commonly used but even less accurately useful "Loup Fork." Like "Arikaree" it will probably continue to be employed in generalization, but must be supplanted by more precisely defined or more local names in accurate paleontological stratigraphy.

OREGON: Name given by Cope to the John Day. He abandoned it in favor of Truckee, and then later accepted Marsh's name, John Day. See Merriam and Sinclair 1907. See John Day.

ORINDA: Lower Pliocene of central California. The vertebrate

fauna is extremely scanty but suggests Ricardo Age. See Merriam 1913, Stock 1921A. See also Pinole Tuff.

PALODURO: Obsolete name sometimes formerly applied to the Goodnight, which see.

PANACA: Lower Pliocene (?) of southeastern Nevada. Named by Stock (1921B) who described a very fragmentary fauna, doubtfully referred to the Lower Pliocene.

PANHANDLE: Local name, proposed by Gidley (1903) for the widespread formation of the Texas Panhandle into which he believed the Blanco, Clarendon, and Rock Creek to be incised. Mammals are extremely rare. Fragments suggested to Gidley an age "not older than the Lower Miocene" (but older than the Clarendon). It may not be a wholly unified formation, and the age of any of it remains very dubious.

PASKAPOO: Paleocene formation of central Alberta. Mammals were first found in these beds by Brown. Matthew (1914) considered them as in part of Paleocene but predominantly of Cretaceous character and referred the fauna to the late Cretaceous. Simpson (1927) restudied and more fully described this collection, showing that the Cretaceous aspect was due to the accidental inclusion of fossils of wholly different origin, and that the real Paskapoo fauna is altogether of Upper Paleocene, Tiffany or Clark Fork, aspect. Russell (1929) found and described several other equally imperfect faunules, all likewise of Upper Paleocene character. Whether closer to Tiffany or to Clark Fork is not yet clear. Probably both are included. These very fragmentary faunas do not represent the whole of Paskapoo time, the exact limits of which are not fixed.

PAWNEE, OR PAWNEE CREEK: Late Miocene of northeastern Colorado. Matthew (1901) at first suggested two successive faunas, both of mingled Miocene and Lower Pliocene aspect, under this name. Subsequent faunal lists (e.g., 1909) make no distinction of zones and list a revised fauna definitely Miocene in character, correlated closely with the Deep River (and later shown to be very exactly equivalent to the Lower Snake Creek).

PAYETTE: Mio-Pliocene of Oregon and Idaho. As summed up by Gazin (1932), material found by Buwalda and others suggests the presence in the Payette of an Upper Miocene and a Lower Pliocene fauna, the latter probably the same fragmentary fauna tentatively called Ironside by Merriam. Gazin describes a relatively rich fauna, the Skull Spring fauna, which he correlates with the Mascall and Virgin Valley.

PHILLIPS RANCH: Middle Miocene of the southern Sierra Nevada,

California. Buwalda (1916) described the lower mammalian fauna of the Monolith Series under this name, considering it Middle Miocene or possibly earlier. Matthew (e.g. 1924) considered it about equivalent to the Sheep Creek (or Lower Sheep Creek).

PINOLE TUFF—ORINDA: A late Tertiary series of California containing vertebrates at San Pablo Bay and the Contra Costa Hills. As listed by Merriam (1913) and by Merriam and Stock (correlation discussed in Merriam 1917) the mammalian fauna may include more than one stage but appears to be of Lower Pliocene age.

PIPESTONE, PIPESTONE CREEK, OR PIPESTONE SPRINGS: Lower Oligocene of western Montana. Douglass (especially 1903) discovered and first described the Oligocene of this region as "White River." Matthew (1903) further discussed the lower fauna, largely of small forms, of the Pipestone or Pipestone Springs Beds, correlating them in general with the "*Titanotherium* Beds" (Chadron) but suggesting that they may belong to the very base of the Oligocene.

PUERCO: Lower Paleocene of the San Juan Basin, northwestern New Mexico. The fauna was originally described by Cope, who included in "Puerco" all the strata between the undoubted Cretaceous and the "Wasatch" on the eastern side of the San Juan Basin. Osborn and Earle definitely distinguished "Lower" and "Upper Puerco" faunas. Matthew (1897) first showed how distinctive these were, and because of this very marked difference restricted the name "Puerco" to the lower beds and gave the name "Torrejon" (suggested by Wortman) to the upper beds. This is now universally accepted, and the name "Puerco" applies only to the older formation as used in all recent literature. Gardner (1910) discussed the stratigraphy, accepting the names "Puerco" and "Torrejon," but proposing to unite them in a "Nacimiento Group" (thus equivalent to the old Puerco of Cope). Sinclair and Granger (1914) made a stratigraphic study which may be considered definitive. They rejected Gardner's group name as unnecessary, retaining "Puerco" in the sense established by Matthew. They established the presence of two distinct fossil zones in the Puerco itself, with somewhat different faunas. These have been distinguished as separate life zones by Osborn, but Matthew, in his final manuscript memoir (to be published posthumously in the near future), considers them not of appreciably different age, the distinctions being those of facies. The Puerco has the oldest known fauna of Tertiary aspect (i.e., with creodonts, ungulates, etc.), and marks the base of the known Paleocene. The only known correlative is the scanty basal Fort Union fauna of the Bighorn Basin.

The Puerco fauna, as now recognized, does not occur at or very near the type locality of Cope's "Puerco," but the present usage is so well established and universally understood that any change on this account seems uncalled for.

RATTLESNAKE: Lower Pliocene of the John Day Basin. The formation was named by Merriam (1901), previous references to it being vague and including its fauna in the Mascall. Merriam (1901) placed it only as Pliocene, perhaps later Pliocene. Merriam and Sinclair (1907) simply reaffirmed its Pliocene age, the fauna being too scanty for exact correlation. Merriam in 1917 correlated it roughly with the Thousand Creek and Ricardo, i.e., Lower Pliocene. Merriam, Stock, and Moody (1925) considered it as about intermediate between the older Ricardo and younger Thousand Creek.

RED ROCK CAÑON: Geographic name for the beds later called Ricardo by Merriam. See, for example, Merriam 1919.

REPUBLICAN RIVER: Lower Pliocene of northwestern Kansas, and, by extension, the corresponding stage of the Pliocene generally. The beds were extensively explored, especially for Marsh, and a large fauna is known, but there is no recent faunal or stratigraphic revision aside from such syntheses as that of Osborn and Matthew (1909) or references in describing individual fossils or faunas of similar age. It was generally placed in the "Loup Fork," "Upper Loup Fork," or "Ogalalla," but the more definite local name has been consistently applied by Matthew and is now generally accepted. Matthew (in Osborn and Matthew 1909) tentatively considered it as slightly later than the "Nebraska" (Valentine), later reaffirming this more positively (1924B). Most recently, Matthew and Stirton (1930B) have, in passing, suggested that the Republican River may be in part composite, with the beds on Sappa Creek and elsewhere to the southwest later than those on Driftwood Creek and to the north. They continue to place the fauna, as a whole, as younger than the Valentine, adding that it seems to be slightly older than their Goodnight-Hemphill (and hence equivalent to Clarendon).

RICARDO: Late Miocene or early Pliocene of the Mohave Desert, California. The series had been called Red Rock Cañon, but Merriam (1915A, 1919) gave the more succinct and explicit name Ricardo in describing the mammalian faunas. In his detailed study, Merriam (1919) held that the Ricardo fauna was considerably more advanced than the Barstow, intermediate between Barstow and Rattlesnake or Thousand Creek, near the Republican River. It is placed as earliest Pliocene, although it might also be considered as latest Miocene (see also Stock

and Furlong 1926). Recent work (under Frick) has not yet been published.

ROSAMOND: Group name for the Tertiary of the Mohave Basin. The presence in these sediments of several quite distinct faunas seems to make the use of such a name inconvenient and unnecessary. See, for example, Merriam 1919.

ROSEBUD: Lower Miocene of southern South Dakota and northern Nebraska. Named and discussed by Matthew and Gidley (1904) who, from the very scanty fauna known to them, considered them as true Miocene but near the bottom of the series, and as possibly equivalent to the Gering. Matthew (1907) later reported a much larger fauna, showing that there are two successive stages, Lower and Upper Rosebud. He then considered the Rosebud as representing the whole of the Lower Miocene, intermediate between John Day (then placed in the Oligocene) and Pawnee. He also correlated these beds tentatively with the Lower Miocene of western Nebraska, Agate Springs, etc., that is, with the Harrison.

RUBY: Early Tertiary, probably at least in part Upper Paleocene, of Mesa County, western Colorado. The name was used by Eldridge (1894—see Patterson, 1933), Gale, Lee, and others, but no vertebrates were described until the recent paper by Patterson (1933) on a specimen of *Titanoides*. The presence of this genus suggests Upper Paleocene age for at least the basal levels of the Ruby formation, without wholly excluding the possibility of Lower Eocene age.

SAGE CREEK: Eocene or Transitional Eocene-Oligocene of Montana. The beds were discovered and named by Douglass (1903). On the basis of a very scanty fauna he called them "Eocene?" but noted some affinity with the Oligocene. Matthew (1909) revised the identifications, giving a list of Middle to Upper Eocene affinities. Peterson (1931), after the discovery of the Duchesne horizon of the Uinta, concluded that the Sage Creek might be intermediate between Duchesne and Chadron. Wood (1933) has recently noted the occurrence of true Middle Oligocene in the same region (see "Cook Ranch"). Apparently several horizons are here represented, but none is as yet adequately known.

SAND COULEE: Lowest true Eocene of the Bighorn Basin, northern Wyoming. The division is of doubtful status. It was established by Granger (1914), for beds between the Clark Fork and the Gray Bull, faunally nearer the latter and subsequently generally considered as the base of the true Lower Eocene. Jepsen (1930) proposed uniting this member with the Gray Bull on the ground that *Homogalax* (*Systemodon*),

supposedly absent in the Sand Coulee, does occur there. As Granger also cited the "generally more primitive character" of the Sand Coulee fauna, there remains some question as to the propriety of uniting the two, although they are clearly very close to each other in age.

SAN PEDRO: A Pliocene series between Benson and Tombstone, Arizona. Mammals discussed by Gidley (1922, 1926). He indicates two distinct faunas, one near the Blanco, the other considerably later. In the present correlation charts these are tentatively listed as the Benson and Curtis faunas, from their localities.

SANTA FÉ: Upper Miocene to Lower Pliocene of north central New Mexico. The fauna of this formation was first described by Cope, who placed it in the "Loup Fork epoch." The fauna, as listed for example by Osborn and Matthew (1909), appears to be of Upper Miocene age and nearly equivalent to the Madison Valley and Barstow. Within the last few years a very large collection has been made for Frick, but no detailed correlation or stratigraphic study has yet appeared. In his recent study of the mastodonts, Frick (1933) suggests that the Santa Fé is less unified than previously supposed and adduces good evidence that it covers the transition from Miocene to Pliocene, with younger horizons equivalent to the Valentine or possibly even slightly later.

SAN TIMOTEO: Pliocene formation of southern California. Scanty fauna described by Frick (1921) indicates a slightly later stage than the underlying Mount Eden. Frick correlated it tentatively with the Blanco. Later work has not yet been published.

SENTINEL BUTTE: A proposed division of the Fort Union group (see Thom and Dobbin, 1924). The Bear Creek fauna of Tiffany, Upper Paleocene, age, was considered by Simpson (1929) perhaps to be in this lithologic member, but on no very good evidence. See Fort Union.

SESPE: A thick terrestrial series in Ventura County, California. Stock (1930, 1933B) reported a mammalian fauna, approximately of John Day age, in the upper part of the Sespe. More recently a wholly distinct fauna probably of Duchesne (transitional Eocene-Oligocene) age has been found in the lower part of this formation. This has not yet been published except in a preliminary abstract by Stock (1933A).

SHEEP CREEK: Middle Miocene of western Nebraska. First named by Matthew and Cook (1909) as a local phase of the "Arickaree" and then considered as equivalent to the Pawnee, Deep River, and Mascall. In his next study (1918), Matthew considered the Sheep Creek as near to or slightly older than Mascall and Deep River and distinctly older than the Pawnee. In 1924, Matthew (1924A) recognized the Sheep

Creek as being a floodplain phase and the Snake Creek a partly contemporaneous channel phase. He confined the name Sheep Creek (in the faunal lists) to the lowest of the three zones then definitely recognized, also called "Lower Sheep Creek." It was then considered as older than the Mascall, and possibly equivalent to the fragmentary Phillips Ranch fauna. See also Snake Creek.

SIESTAN: Lower Pliocene of central California. The extremely scanty vertebrate fauna suggests Ricardo age. See Merriam 1913, Stock 1921A.

SKULL SPRING: Upper Miocene of southeastern Oregon. Gazin (1932) has used this name to designate a fauna, probably from the Payette Formation, which he correlates with the Mascall and Virgin Valley. See Payette.

SMITH RIVER: See Deep River.

SNAKE CREEK: Upper Miocene and Lower Pliocene of western Nebraska. Named and discussed as a large faunal unit by Matthew and Cook (1909), as a local facies of the "Ogalalla." They considered it as near the Republican River, but with "modernization . . . more apparent." Matthew (1918) later recognized the probability that the fauna might not be a unit but might range from Upper Miocene into the Lower Pliocene. He was unable to differentiate it stratigraphically at that time, although (in Osborn 1918) he did divide the horses into three groups of supposedly different age. In his definitive study, Matthew (1924A) recognized that "Snake Creek" had been applied to a channel phase and "Sheep Creek" to a floodplain phase in part contemporary. He recognized the presence of three successive faunas, the first two in both channel and floodplain sediments and the last only in channels, distinguishing these as *Merychippus primus*, *Merychippus paniensis*, and *Hipparion affine* zones, from oldest to youngest. In his faunal lists he confined the name Sheep Creek to the earliest zone, and called the other two Lower and Upper Snake Creek. The lower Snake Creek he showed to be exactly equivalent to the Pawnee Creek. The Upper Snake Creek is said to be comparable to the Republican River, although the correspondence is not exact and some forms suggest a somewhat later age. (The beds may contain a Goodnight-Hemphill equivalent.) Both in 1918 (in Osborn 1918) and 1924, Matthew very doubtfully distinguished a still later horizon, in dune-sands but still of Pliocene age, the "*Pliohippus leidyanus* Zone." The fauna is fragmentary and doubtful and has not been proven distinct, correlated, or given a geographic name.

SWEETGRASS OR SWEETGRASS COUNTY: Name, of no definite stand-

ing, sometimes applied to the Fort Union faunas of the Crazy Mountain Field, Montana. See Fort Union.

SWIFT CURRENT: Early Tertiary deposit of northern Saskatchewan. The mammalian fauna has not been published, but was reported by L. S. Russell and R. T. D. Wickenden (1933). It seems to be of Uinta age, probably Uinta C, although possibly Duchesne. (The name is not to be confused by its use as a locality name, e.g., in Osborn 1918, for the later Cypress Hills fauna.)

TECUJA OR TECUYA: Late Oligocene or early Miocene of the south end of the San Joaquín Valley, California. The very scanty fauna was described by Stock (1920) who gave the name Tecuja to the mammal-bearing beds, terrestrial in origin, intercalated in the marine series, leaving in doubt whether they belong in the San Lorenzo, Vaqueros, or Monterey formations or groups. The age is given as late Oligocene or early Miocene and tentative correlation is with the John Day.

TEHAMA: Upper Pliocene of northern California. The formation was named by Russell and Vander Hoof (1931) who concluded from rather scanty fossils that it is in part equivalent to the Upper Etchegoin (=Blanco) and in part to the slightly later Lower Tulare. Later work by Vander Hoof (1933) places it in the uppermost Pliocene, distinctly later than Upper Etchegoin.

TEMBLOR: Marine Miocene of southern California. See North Coalinga.

THOUSAND CREEK: Pliocene formation of northwestern Nevada. Merriam (1910–11, 1917) has listed and discussed the fauna and suggests that relationship to the Rattlesnake is close but that the Thousand Creek may be a little later. He placed it later than the Snake Creek (as known in 1911) and earlier than the Blanco. Matthew and Stirton (1930) have adduced evidence that the Thousand Creek is about equivalent to their Goodnight-Hemphill, i.e., a late phase of the Lower Pliocene.

TIFFANY: Upper Paleocene of southeastern Colorado (north of the San Juan Basin). Gidley obtained the first fragmentary mammals, and Granger (1917) obtained a good fauna, discussed the correlation and stratigraphy and gave the name "Tiffany" to this very distinctive horizon. He considered the beds as stratigraphically part of the Lower Eocene, "Wasatch," series, but as faunally belonging to a final Paleocene phase, later than the Torrejon. Matthew and Granger have described some of the fauna, but a definitive description has not yet appeared. Granger correlated the Tiffany with the Clark Fork. Recent work by Jepsen (1930) has revealed a Tiffany equivalent beneath the typical

Clark Fork, and there are some faunal distinctions, so that it is evident that the Tiffany is a distinctive and slightly earlier stage.

TONGUE RIVER: A division of the Fort Union group. A few fossils of apparently Torrejon age have been found in supposedly Tongue River sediments. See Fort Union.

TORREJON: Middle Paleocene of the San Juan Basin, northwestern New Mexico. At first included in the "Puerco" of Cope, but distinguished by Matthew who restricted the name "Puerco" to the underlying formation (see "Puerco"). As with the Puerco, Sinclair and Granger (1914) distinguished two fossil levels in the Torrejon, considered separate life zones by Osborn but only as different facies of essentially contemporaneous faunas by Matthew. The Torrejon was considered as Upper Paleocene (or "Basal Eocene") until 1917 when the discovery of other faunas (Tiffany, Clark Fork) between the Torrejon and the undoubted true Eocene, made it more convenient to call the Torrejon Middle and these new faunas Upper Paleocene.

TRUCKEE: Later Miocene of western Nevada. The beds were named by King who considered them to include the series now universally called John Day, and the name was at one time used for the John Day by Cope, but Buwalda (1914) has shown that the typical Truckee is of much later age. The evidence is extremely scanty, but it shows that the beds are at least as young as the Middle Miocene, probably considerably younger.

TULARE: Upper Pliocene of the western border of the San Joaquin Valley, California. Merriam (e.g., 1917) states that two specimens of *Hyaenognathus* and *Ischyrosmilus* probably came from the Tulare, but this was not positively established. More recently, Matthew and Stirton (1930) recorded the definite presence of *Hyaenognathus* in place in the Lower Tulare. The formation is later than the Upper Etchegoin and represents part or all of the Upper Pliocene, and possibly extends into the Pleistocene (see e.g., note and references in Russell and Vander Hoof 1931).

UINTA: Upper Eocene of the Uinta Basin, northeastern Wyoming. The rich fauna of this basin was discovered and first described by Marsh. Peterson (1895) divided the beds into Uinta A, B, and C. The previously known fossils were all from the Upper Uinta, or Uinta C. This subsequently (e.g., Osborn and Matthew 1909) was called "true Uinta," and the lower beds sometimes designated by some such circumlocution as "later Eocene of the Uinta Basin," but they, too , are now universally admitted into the Uinta Formation. The lowest faunal zone was at first

included in Uinta A, but later work by Peterson (chiefly faunal, but see also 1931 and Peterson and Kay 1931), Douglass (1909B), Riggs (1912) and Osborn (especially 1929) has resulted in the present arrangement, with Uinta A including only barren basal beds, Uinta B with a rich fauna, by Osborn divided into B_1 ("*Metarhinus* zone") and B_2 ("*Eobasileus-Dolichorhinus* zone and "*Amynodon* sandstone"), and Uinta C ("*Diplacodon* zone"). Uinta C formerly included not only the Upper Uinta, "true Uinta," or "*Diplacodon*" fauna (C_1 of Osborn) but also overlying supposedly barren beds (C_2 of Osborn). Peterson (1928) restricted Uinta C to the classic faunal zone and referred the overlying beds at first to the Brown's Park, then (1931) separated them as the Duchesne (which see).

The name "Uinta" has come to be used as a more or less generic name for Upper Eocene mammal-bearing beds. The "Uinta" of Beaver Divide, Wind River Basin, Wyoming (Sinclair and Granger 1911), is considered by Peterson and Kay (1931) as probably intermediate in age between Uinta C and Duchesne. It has not yet been given a needed local name.

VALENTINE: Miocene-Pliocene, or lowest Pliocene, of Nebraska. It has long been known that an early "*Hipparion* zone" fauna occurs along the Niobrara River and Little White River of Nebraska (these river names sometimes applied to the fauna). It was included in the "Loup Fork" of Hayden, was also called "Loup Fork" by most other early students, and includes the "*Cosoryx* beds" or Nebraska Formation of Scott (1894). The zone or its equivalents were also included in Darton's "Ogalalla" (see Darton 1905A). Essentially the same formation is also apparently included in the Devil's Gulch of Barbour (1914), although this series also seems to contain older and perhaps also younger faunas. This horizon near Fort Niobrara was named Valentine by Barbour and Cook (1917) and Fort Niobrara by Osborn (1918). Following Matthew (e.g. 1924B) and others, the name Valentine is here retained for this fauna. Its position, marked by the earliest appearance of the typical Lower Pliocene horse genera, is between the Pawnee and Republican River, but closer to the latter, and it has been variously classed as Upper Miocene and Lower Pliocene.

VAQUEROS: See North Coalinga.

VIRGIN VALLEY: Miocene formation of northwestern Nevada. Merriam (1911) described the fauna, which he correlated with the Mascall, Deep River, and Pawnee.

WASATCH: A name now of dubious status, but widely employed for

the first phase of the Lower Eocene. The name was originally applied by Hayden to a group of formations in the Wasatch Basin near Evanston, Wyoming. Veatch (1907) subsequently subdivided the group, applying the name Knight to the upper divisions (the lower divisions being Almy and Fowkes). Fossils are found only in the Knight and even there are very scarce and poorly preserved. In the meantime Cope and others had extended the name "Wasatch" to the very rich Lower Eocene faunas of the Bighorn Basin and also of the San Juan Basin. Sinclair and Granger (1911, 1912), accepting this correlation, applied the name Knight to the Bighorn "Wasatch," as supposedly equivalent to the fossiliferous part of the type Wasatch. But Granger (1914) later found that the Knight fauna is not equivalent to that previously almost universally called "Wasatch," but to the newly discovered earlier fauna of the Wind River series, the Lysite of Sinclair and Granger. The anomalous situation thus arose that the known fauna of the type Wasatch is later than the accepted "Wasatch" fauna, and that the latter does not occur in the Wasatch Basin. It cannot even be demonstrated that the Almy and Fowkes, without known fossils, are of that age. The continued use of the name "Wasatch" thus became very ambiguous. Granger (1914) applied the name Gray Bull to the Bighorn Basin beds previously called "Wasatch," and Largo and Almagre to the New Mexico "Wasatch." The name Wasatch is very widespread and firmly embedded in the literature and will doubtless continue to be used in a sense which seems, strictly speaking, erroneous, that is for the beds and the fauna now less ambiguously called Gray Bull.

Osborn (1929) has continued to use "Wasatch" for the whole Lower Eocene of the Bighorn Basin. He has also lettered the horizons of the "Big Horn" or "Big Horn Wasatch" as follows: "Big Horn A" = Clark Fork; "Big Horn B" = Sand Coulee; "Big Horn C" = Gray Bull; "Big Horn D" = Lysite; "Big Horn E" = Lost Cabin.

WASHAKIE: Middle to Upper Eocene of the Washakie Basin, southern Wyoming. The beds were discovered and named by Hayden, and Marsh and Cope both studied the stratigraphy and faunas. These were also studied by Osborn, McMaster, Scott, and Wortman. Definitive stratigraphic study is that of Granger (1909) who recognized a division into Washakie A and Washakie B. With Matthew he correlated Washakie A with Bridger C and D, and Washakie B with "Uinta A and B" (Uinta B of present usage).

WELLER: Name applied by Peterson (1928) to the lower part of the Miocene Brown's Park formation, including at its top, and at about the

middle of the whole Brown's Park, the sandstones from which the bulk of the fauna was derived. See Brown's Park.

WHITE BUTTE: Oligocene of North Dakota. Douglass (1909A) described as "White River" the outlying Oligocene of this region. The reported fossils are for the most part of Lower Brulé age, but Chadron and Upper Brulé are probably also present in the vicinity.

WHITE RIVER: The classic Oligocene of the Big Badlands, South Dakota, and, by extension, of the whole plains and Rocky Mountain region. These famous deposits have been more extensively explored than any other geologic group in the country and the literature on them is voluminous. The stratigraphy is well summed up in Osborn and Matthew (1909), Osborn (1918), Osborn (1929), especially the Chadron, and O'Harra (1920). The name White River was applied by Marsh and Hayden. Hayden and Leidy divided the series into horizons A, B, and C, A including the lower division of later work, B and part of C the middle, and part of C the upper. Leidy also applied the name *Titanotherium* Beds to the lower and *Oreodon* Beds to the middle divisions. Wortman (1893) called the lower division "*Titanotherium* clays and sandstones," the middle "*Oreodon* clays and *Metamynodon* sandstones," and the upper "*Leptauchenia* clays and *Protoceras* sandstones." The clay and sandstone divisions of each series are not of different ages but different facies (see Matthew 1901). Darton (see Darton 1905A) gave the name Chadron to the lower and Brulé (often written and pronounced Brule) to the middle and upper, and these continue to be the current geographic-stratigraphic names for the plains White River. The name "White River" has come to be used as a general term for terrestrial deposits of this age and has been applied to numerous more or less isolated Oligocene deposits in Colorado, Wyoming, Montana, and elsewhere. Only a few of the better known of these have received local names. The various "White River" deposits reported by Douglass in Montana and the "White River" of Bates Hole, Wyoming, are the most important of these isolated areas not yet designated by their own geographic names.

WIND RIVER: Lower Eocene of the Wind River and Bighorn Basins, Wyoming, a name now used rather in a general sense for later Lower Eocene than for any specific formation. The name was first applied by Hayden and the fauna described by Cope. Granger (1910) and Sinclair and Granger (1911) found that the whole Wind River series of the Wind River Basin contains two quite distinct faunas, and divided their "Wind River series" into Lysite (below) and Lost Cabin (above). All collections described as Wind River previous to 1911 came from the

upper beds, and thus "Wind River" as used in older faunal studies is the Lost Cabin fauna of more recent work. The name "Wind River" has come to be applied generally to this part of the Eocene, between the classic "Wasatch" and the Bridger. See also Lysite and Lost Cabin.

WOOD MOUNTAIN: Miocene of Saskatchewan. Sternberg (1930) applied the name "Wood Mountain gravels" to beds containing scanty and fragmentary vertebrates considered by the present writer (in Sternberg 1930) to be of Middle or Upper Miocene age.

WRAY: Lower Pliocene of Yuma County, Colorado. Fauna identified by Cook (1922) who correlates it with the Upper Snake Creek.

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