The evolution of the horse family : as illustrated in the Yale collections / by Richard S. Lull.

YALE UNIVERSITY

Peabody Museum of Natural History

GUIDE No. 1

THE EVOLUTION of the HORSE FAMILY

CLIQUE, A MULTITOED MODERN HORSE

BY RICHARD S. LULL, PH.D.

Associate Curator in Vertebrate Paleontology.

REPRINTED FROM THE AMERICAN JOURNAL OF SCIENCE,
VOL. XXIII, MARCH, 1907.

Peabody Museum of Natural History.

FOUNDED IN 1866 BY GEORGE PEABODY OF MASSACHUSETTS.

THE EVOLUTION OF THE HORSE FAMILY

[FROM THE AMERICAN JOURNAL OF SCIENCE, VOL. XXIII, MARCH, 1907.]

The Evolution of the Horse Family as Illustrated in the Yale Collections.

By RICHARD S. LULL, Ph.D.

Associate Curator in Vertebrate Paleontology.

Part I.

It is seldom that the paleontologist is able to show so complete a series representing the evolution of a race of land ani-

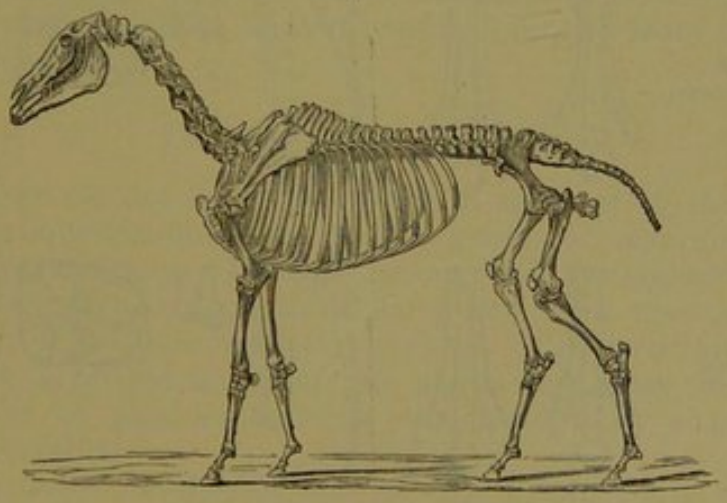

Fig. 1. Skeleton of the modern horse, *Equus caballus*. (After Marsh.)

mals as in the case of the horse, and it is even more exceptional that an institution is fortunate in having so comprehensive a collection as that now in the Peabody Museum at Yale, which was brought together through years of constant watchfulness on the part of the late Professor Othniel Charles Marsh.

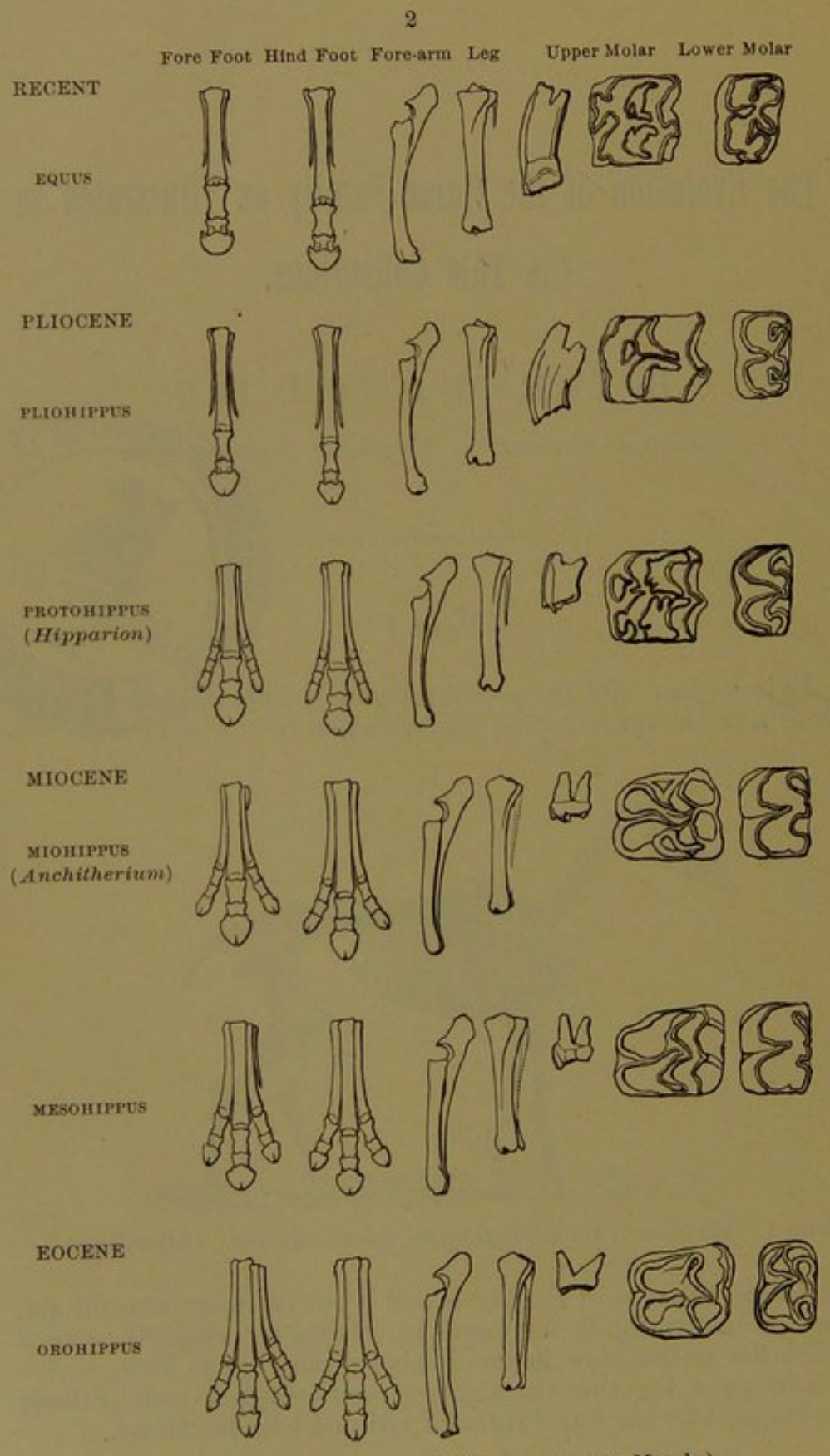

FIG. 2. Genealogy of the Horse. (After Marsh.)

This collection was begun in our western country in 1868, before the completion of the Union Pacific Railroad, and subsequently for several years the explorers had an escort of U. S. cavalry for protection from the assaults of the Indians. In 1876, the collection was seen and studied by Professor Huxley, profoundly altering his views in regard to the place of evolution of prehistoric horses.

The completeness of our record of the evolution of the horse tells us something of the enormous numbers of ancestral forms which must have existed in the more than two million years that have elapsed since the first diminutive horse appeared in North America. While not strongly given to migration, in the course of time these animals wandered over the entire world with the exception of such inaccessible places as Australia and the Oceanic islands.

It would seem that the original stock was of Eurasian derivation, though the great theater of the evolutionary drama was soon transferred to North America, the Eurasian, African, and South American horses which appear from time to time being in all probability of North American origin. As we shall see, the ultimate fate of the horses in both North and South America was extinction, all wild horses of our own time, including the asses and zebras, being confined to Asia and Africa. The apparently wild bands of our western plains and those which roam over the pampas of South America are feral, which means that they are the descendants of domestic horses that have escaped from human bondage, largely from the early Spanish explorers.

The Origin of the Horse.

While we do not know the ultimate ancestor of the horses, we are unquestionably sure of the group of mammals from which they sprang. In this group, the Condylarthra, the animals are five-toed on both hand and foot, also resting a great part of the sole upon the ground. The wrist and ankle bones are arranged in series one above the other in such a manner as to produce a weak structure when exposed to splitting strains.

Phenacodus primævus, one of this group found by Professor Cope, was hailed by him as the "five-toed horse," and its figure has appeared in many text-books as such. It is far too large and in some respects too specialized to be in the equine series, but its feet give one a very good idea of the character of those of the antecedent horse.

The first undoubted horselike animal appearing in the rocks of North America is a little creature not more than eleven

inches high, known to science as *Eohippus*. This interesting animal has already made a long stride in the direction of the modern horse, as the number of toes is now reduced to four in front and three behind, and the bones of the wrist and ankle have shifted so as to interlock, which greatly strengthens the foot.

The Evolutionary Changes.

From the Condylarthra and *Eohippus* the course of evolution is largely one of adaptation to the necessities of food get-

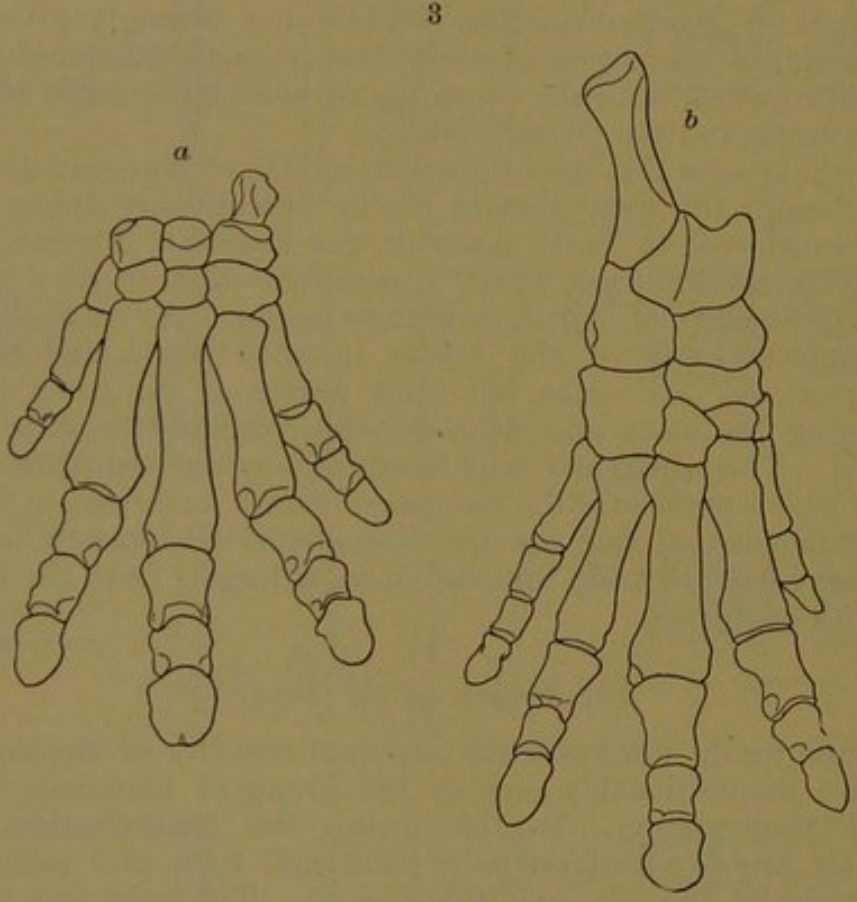

FIG. 3. *a*, Fore foot and *b*, hind foot of *Phenacodus primævus;* drawn from casts from the American Museum of Natural History. One-third natural size. (Original.)

ting and safety. To the one the horse owes the marvelous perfection of the grazing mechanism, as seen in the lengthened jaws and in the teeth; to the other, the fleet limbs and graceful contour of the body and the increase in stature. These adaptations are entirely mechanical, and, while tending toward greater and greater perfection on the whole, are not always of a progressive character; as the loss of side toes is distinctly retrogressive.

Changes in the Feet and Limbs.—The adaptation for speed includes an actual lengthening of the limb, more especially in the lower portions, the thigh and upper arm remaining comparatively short. The muscles which actuate the legs are near the body, their power being transmitted by long slender tendons. This not alone produces a more graceful member, but, as the center of gravity is high, the limb though long moves quickly, like a short pendulum, combining rapidity of movement with a lengthened stride.

The foot changes from its primitive posture, in which more or less of the sole rests on the ground, to that in which the weight is borne on the tips of the toes, the claw, or nail, becoming modified into a hoof. The reduction of the lateral

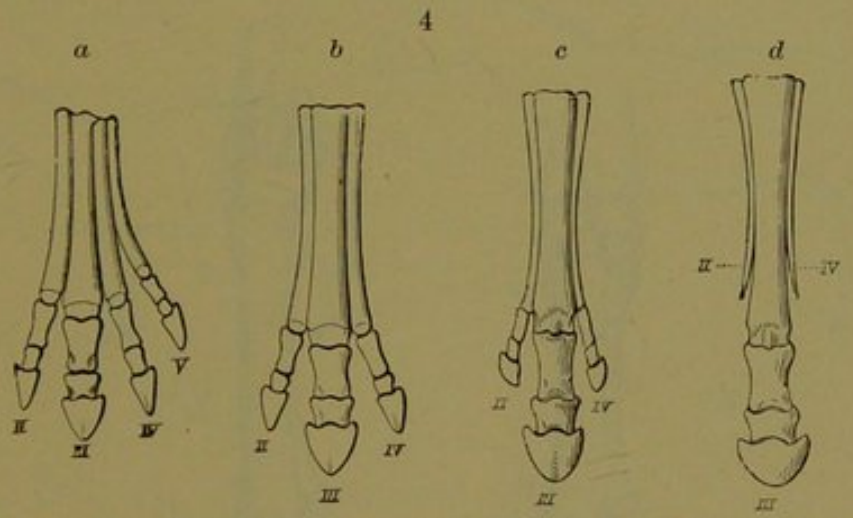

FIG. 4. Fore feet of *a*, *Orohippus* (Eocene): *b*, *Miohippus* (Miocene); *c*, *Hipparion* (Pliocene); *d*, *Equus* (Quaternary). (After Marsh.)

digits invariably follows such a change of posture, especially if the animal is becoming adapted for speed on hard ground. In the horse the axis of the foot lies in the third digit, which grows proportionately longer and stronger as the lateral ones reduce.

The pendulum-like motion of the limbs being all in one plane, the joints between the bones become pulley-like through the formation of interlocking tongues and grooves, which effectually limit any lateral motion. There is also a reduction of the ulna in the fore-arm and of the fibula in the lower leg, as these bones, especially the former, are associated with more varied movement.

In this evolution the hinder foot is the more progressive, as the fore limb retains its general utility for a longer time. Finally, however, after vast ages, the fore foot overtakes the hind one, and thenceforth the degree of evolution in each is

the same. Still, it is curious to note that, among living horses, in instances of reversion to ancestral conditions the fore foot is more apt to exhibit well-developed atavistic toes, showing that in it the reminiscent tendencies are stronger.

The Yale collection contains specimens representing three examples of the occurrence of extra toes in the modern horse. They may be monstrosities of the same nature as the occasional sixth finger in man and the multiple digits frequently occurring in the domestic cat. They seem, however, to have a deeper significance and to be true cases of atavism, or reversal to an ancestral condition, although they are abnormal in the

5

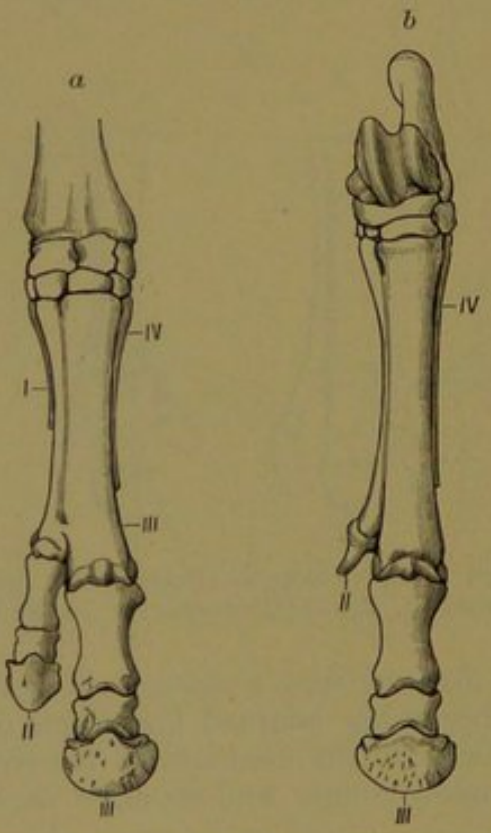

Fig. 5. *a*, Fore foot and *b*, hind foot of Clique, a multitoed modern horse. One-eighth natural size. (After Marsh.)

development of one lateral digit only, as we know of no two-toed fossil horses. Not only has the toe itself reappeared, but in the wrist and ankle are bones with all their old forms and associations, which have not been normally present since Oligocene times. Pliny, the elder, who lost his life in the destruction of Pompeii, A. D. 79, tells us in his Natural History: "It is said, also, that Cæsar the dictator had a horse which would allow no one to mount him but himself, and that its fore-feet were like those of a man." Unquestionably this

6

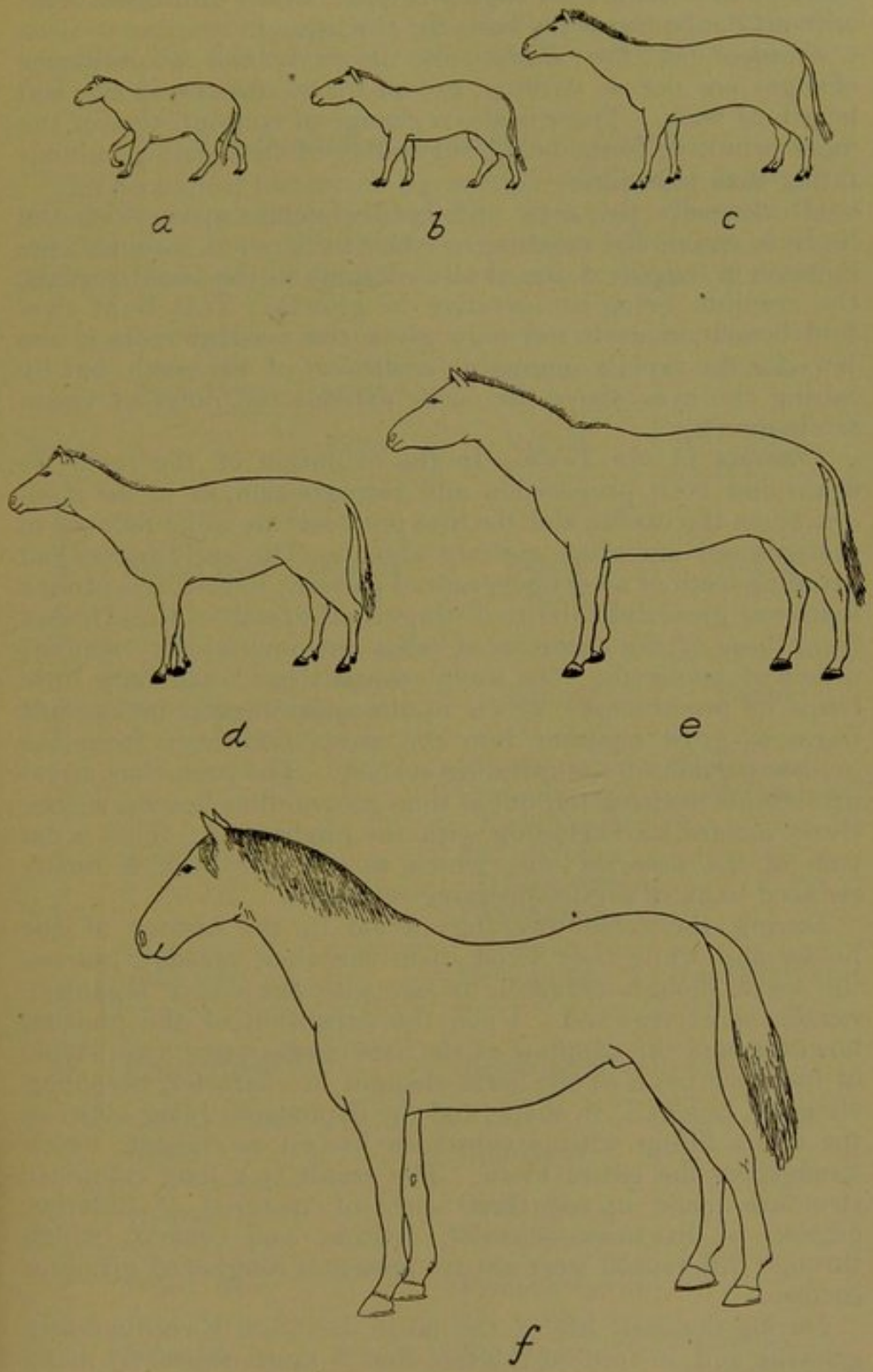

FIG. 6. Prehistoric horses compared with the modern horse in size and contour; *a*, *Protorohippus* (Wind River Eocene); *b*, *Orohippus* (Bridger Eocene); *c*, *Mesohippus* (Oligocene); *d*, *Merychippus* (Miocene); *e*, *Pliohippus* (Pliocene); *f*, *Equus* (Recent). (Original.)

description is somewhat highly colored, but a multitoed horse without doubt forms the basis for the legend.

Changes in the Body.—In the body the evolutionary changes are not so striking, except for an increase in size and length of back. There is also a change of contour, that of the more primitive forms being suggestive of flesh-eating animals rather than horselike.

Of necessity the neck and head elongate apace with the limbs to enable the creature to reach the ground, although the increase in length of the skull is largely in the facial portion, the cranium being conservative in growth. This is of two-fold benefit, since it not only gives the needful room in the jaws for the rapidly increasing armament of the teeth, but by raising the eyes above the earth extends the range of vision while grazing.

Changes in the Teeth.—In the evolution of the teeth we again find both progression and retrogression, as in the modern horse the canine and the first premolar are alike reduced to vestiges and are often entirely absent. The early horses had grinding teeth of a very generalized pattern; indeed, it is often a matter of great difficulty to distinguish the teeth of these horses from those of the ancestors of what are now widely removed orders of mammals. On their crowns these teeth bore little cusps or prominences, which in the quadrangular molars just begin to grow together into the crests that later form the greater portion of the grinding surface. The premolars are at first simple in character, but as time goes on they become successively molar-like, beginning with the hindermost. This is not true of the anterior one, which, as we have seen, is finally reduced to an often disappearing remnant.

During the forest-dwelling period in the history of the horses and while they lived upon succulent meadow grasses, the teeth, though increasing in size with the entire organism, remain short crowned. Upon the expansion of the prairies, however, and the adoption of the harsh grasses as a main staple of food, the tooth of the horse changes in character, becoming elongate, prismatic in shape, and the depressions lying between the crests filling with a substance known as cement, which strengthens the entire tooth. The result is a long columnar structure made up of three sorts of material of different degrees of hardness,—enamel, dentine, and cement, which through differential wear always present a roughened grinding surface.

During the early life of the horse the tooth is continuously growing and, in spite of the fact that it must constantly move outward to compensate for wear, the root penetrates deeper and deeper within the jaw until fully formed. The outward

movement still continuing, the tooth now gradually shortens until in extreme old age it is practically consumed. The total length of the tooth is nicely calculated to meet the needs of a full measure of life.

The Geological Occurrence of Horses.

The geological history of the earth is immensely long and it is only very recently, geologically speaking, that the land animals more or less like modern mammals have been evolved. The earth's history begins in the deepest obscurity, the first

	American Formations	South America	North America	Eurasia
Recent		Extinct	Extinct	Equus (also Africa)
Pleistocene	*Equus Beds*	Equus	Equus	Equus
Pliocene	*Blanco* *Palo-Duro*	Equus Hippidion	Equus	Equus
Miocene	*Loup Fork*		Pliohippus Protohippus Neohipparion Merychippus Hypohippus Parahippus	Hipparion Anchitherium
Oligocene	*John Day*		Miohippus	Anchitherium
	White River		Mesohippus	
Eocene	*Uinta*		Epihippus	
	Bridger		Orohippus Helohippus	
	Wind River		Protorohippus	
	Wasatch		Eohippus	Eohippus Hyracotherium
	Basal Eocene		Horses unknown	

glimmerings of life coming to us not as remains showing form and structure, but as graphite, limestones, and iron ores, which are the chemical effects of organic life. This period is of vast duration; then, almost suddenly, myriads of forms of lowly organization appear, out of which are slowly evolved animals and plants of higher and yet higher types.

At length, when the plants had sufficiently spread over the land, there gradually emerged from the waters animals capable of breathing the air, among them creeping amphibians like the salamanders of today. From these arose the lowly reptiles, but during the long period known to geologists as the Paleozoic æon no higher forms of life appear. Then followed the Mesozoic æon, when reptiles flourished, out of which arose the higher animals, both birds and mammals. Mammals lived during the Mesozoic, probably in abundance, but our record of them is very meager, doubtless owing to the conditions under which they existed. In the Cenozoic æon, the age of mammals, the geological record is rich and easily decipherable.

In the basal strata of the Cenozoic age the mammals appear in great profusion, variety, and some of considerable size, indicating a migration from a region as yet unknown. Among these early mammals no horselike ancestors have been yet discovered, undoubted horses first appearing in the genus *Hyracotherium* from the London Clay of England, the ancestor of *Eohippus*.

The sequence of genera is given in the table on p. 169.

Part II.

Synopsis of the Geological History of Horses.

EOCENE PERIOD.

During Eocene times North America was clad with forests in which grew both evergreen and deciduous trees distinctly modern in character. The moist climate gave rise to many streams and lakes, along the shores of which grew sedgy meadows that in turn gave rise to grassy plains. These were the conditions under which the horses made their first appearance, and the increasing development of grass lands gave the initial trend to their evolution.

During the earlier ages of the Eocene period there was but little differentiation on the part of the various mammalian orders, and the ancestral horse is here unrecognized or undiscovered. The earliest known horses appear in the rocks of the Wasatch age, and while they are found in both the Old and the New Worlds the more primitive are of the former, as shown in

the genus *Hyracotherium* from the London Clay, known only by the skull.

The genus *Eohippus* has teeth of a very similar pattern, but more advanced in that the cross crests are somewhat more distinct than in *Hyracotherium* and, unlike the latter, the fourth premolar is beginning to assume the form of a true molar. The hand bore four digits, with a vestige of the first (thumb) in the form of a splint bone probably entirely concealed within the skin. The more progressive hind foot had but three toes, with a remnant of the fifth.

Eohippus was a small animal about eleven inches in height at the shoulder and in general suggestive of the carnivores

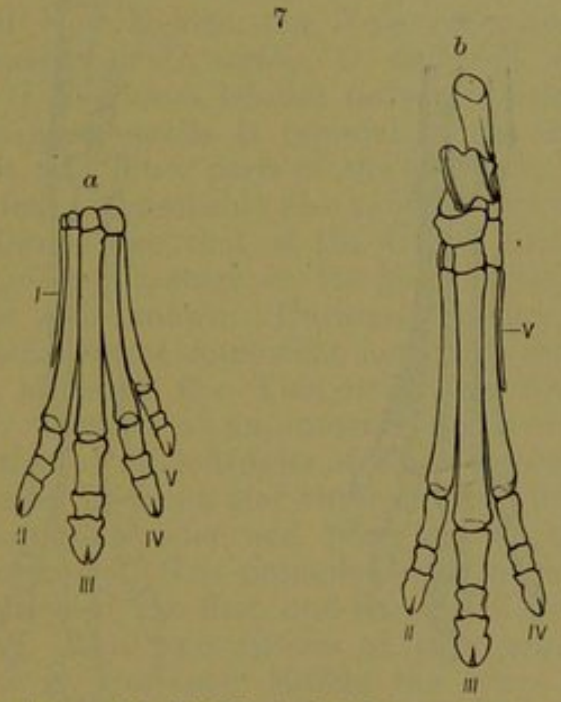

FIG. 7. *a*, Fore foot and *b*, hind foot of *Eohippus pernix*. One-half natural size. (After Marsh.)

rather than of the ungulates of to-day. The back was arched, the head and neck were short, and the limbs of moderate length, showing no especial adaptation for speed. This genus has a remarkable geographical range, having apparently originated in western Europe (England) and migrated by way of Asia and what is now Bering Strait as far southeast as New Mexico. This migration of *Eohippus* shifted the scene of the evolutionary drama to our own country, for, while the remains of succeeding genera are increasingly numerous in North American rocks from the Wasatch on, it is only from time to time that European representatives appear, in each case evidently derived from migratory North American types. The Yale Museum

contains the type specimens of *Eohippus pernix* and *E. validus* and numerous jaw, teeth, and limb bones referable to the genus.

During the succeeding Wind River age *Protorohippus* appears, representing the so-called third stage in the evolution of the horse. In stature somewhat larger than *Eohippus*, this animal reached the height of fourteen inches, and while the beginnings of speed are evident from the increasing length of limb, the bodily contour is still primitive. The hand seems to have lost the vestigial thumb and a shortening of the outer-

8

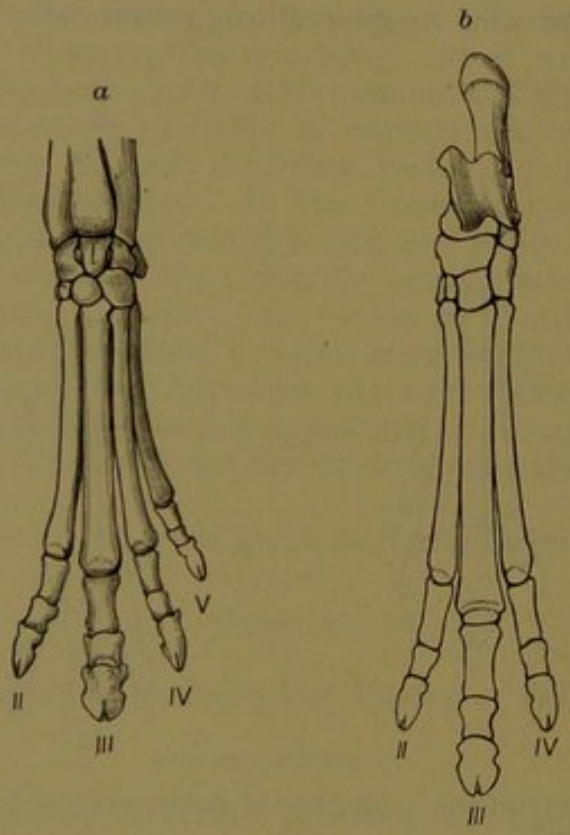

FIG. 8. *a*, Fore foot and *b*, hind foot of *Orohippus agilis*. One-half natural size. (After Marsh.)

most digit indicates that the tendency toward a three-toed condition is already strong. The foot is much like that of its predecessor with three functional toes. The dentition shows progress in the further perfection of the crests, in the fact that the fourth premolar is quite molariform, and that the third is beginning to assume the shape of a molar. *Protorohippus* had a very limited geographical range, being found thus far only in Wyoming and Colorado. In the Yale collection the genus is represented by a cast of the skull of *P. ventricolus* from the mounted specimen in the American Museum of Natural History.

In the rocks of the Bridger age two genera of horses are found, *Helohippus* and *Orohippus*, the former being known only by the teeth. The type specimen of *H. pumilus* Marsh is in the Yale collection. *Orohippus*, on the contrary, is well known, and represents the fourth stage in the evolutionary series. It is but little advanced over *Protorohippus*, which it somewhat exceeds in size. The foot structure is much the same, but the teeth show the most notable improvement over those of its predecessor. The third premolar has assumed the full molar form and the second is beginning to do so. The space, or diastema, between the cropping and grinding teeth is rapidly increasing, owing to the lengthening of the jaws.

The genus *Orohippus* includes a number of species from Wyoming and New Mexico, the Yale collection containing the type specimens of *O. agilis*, *O. ballardi*, *O. major*, *O. pumilus*, and *O. uintanus*, besides numerous other specimens. That of *Orohippus agilis* is especially fine, consisting of a skull, fore foot, and other parts of the skeleton, while a lower jaw and hind foot are probably also referable to this species.

The final Eocene age, that of the Uinta, brings into view the fifth, or *Epihippus*, stage in the horse series, but unfortunately one not well known. Curiously enough, the average size of the species seems somewhat less than that of the preceding genus, although the Yale collection contains a hind foot and other portions of an unnamed form of much larger size, rivaling that of *Mesohippus* of the Oligocene. *Epihippus* has four toes in front and three behind, but the lateral ones are becoming shorter and bear less of the creature's weight than formerly. The premolar teeth are all molariform with the exception of the first, and the crests are almost completely formed. But two species of this genus have been described, both by Professor Marsh, the types being in the Yale collection. They are *Epihippus gracilis* and *E. uintensis* from Utah.

OLIGOCENE PERIOD.

During Oligocene times, much the same conditions prevailed as in the Eocene. The drying up of streams and lakes, due to increasing aridity of climate, gave great impetus to the development of broad meadow lands and to the true prairie as well. Thus there were three conditions,—woodland, meadows, and dry prairie, which seem to have given rise to several parallel lines of evolution, some of which terminated, being overcome in the struggle for existence, while others flourished and gave rise to the horses of the Miocene.

But two genera of Oligocene horses are recognized, *Mesohippus* and *Miohippus*, the former being the more primitive,

though the differences between them are slight. *Mesohippus* from the White River beds, the sixth stage, is three-toed in both fore and hind feet, with a rather long splint bone representing the fifth digit of the hand, while in the foot there is no trace of the outer one remaining. The entire series of cheek teeth except the small first premolar is molariform,

9

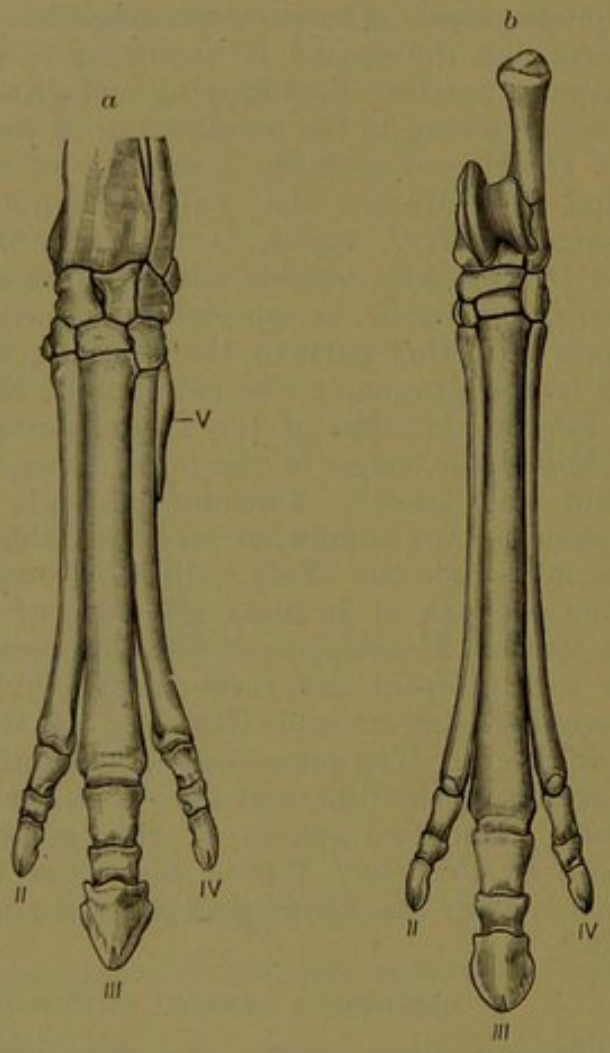

FIG. 9. *a*, Fore foot and *b*, hind foot of *Mesohippus celer*. One-half natural size. (After Marsh.)

while the crests are not only well developed but there is a tendency toward a further complication of the grinding surface.

Mesohippus bairdi, the best known form, averaged about eighteen inches in height, a slender-limbed creature, very well adapted for speed. *Mesohippus intermedius* was much larger and in some ways unprogressive, which, together with the con-

ditions under which it is found, may be taken as indicative of a conservative forest-dwelling form in contrast with the progressive plains-living type. Yale Museum contains a number of fine skulls and other parts of the skeleton of *Mesohippus*, including the smaller Oreodon-bed types as well as the larger species from the Protoceras beds. The former specimens include a nearly perfect skull of a new-born foal of pathetic interest.

10

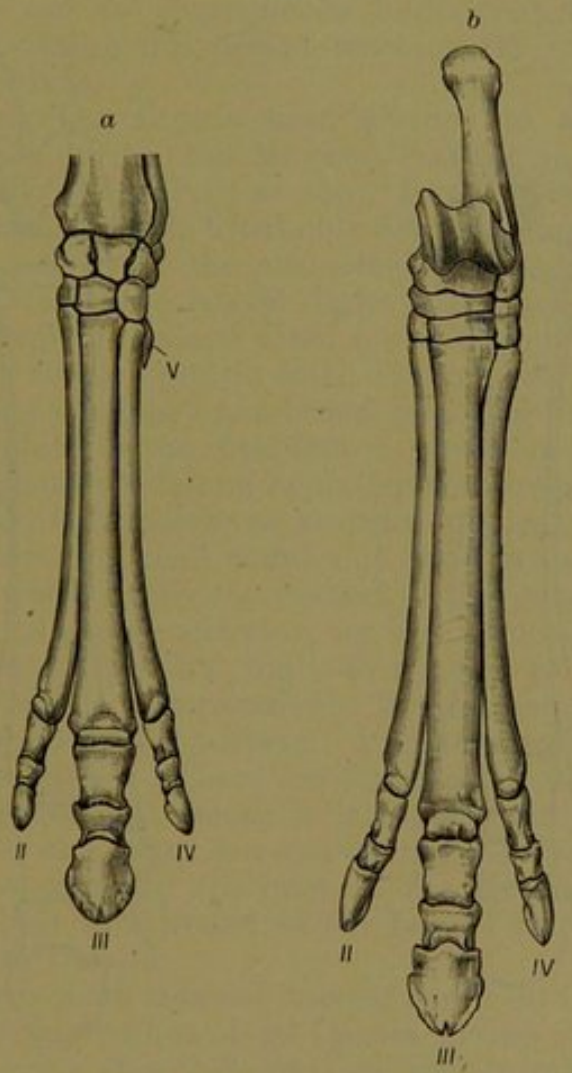

FIG. 10. *a*, Fore foot and *b*, hind foot of *Miohippus anceps*. One-third natural size. (After Marsh.)

Miohippus of the John Day beds represents the seventh stage in the evolution of the horse. It is larger than *Miohippus*, averaging at least twenty-four inches at the withers. Distinctions between the two Oligocene genera are not easily found, the main differences, other than size, being the shorter splint of digit five in the hand, and a somewhat greater com-

plexity of the grinding teeth. *Miohippus*, which may have existed into the Miocene, is contemporaneous with the European *Anchitherium*, a similar genus, to which the species of *Miohippus* were formerly referred. The European genus is a derivative of the latter. *Miohippus anceps* and *M. annectens* were both described by Marsh, and the types are in the Yale Museum. In addition there is a perfect skull from the

11

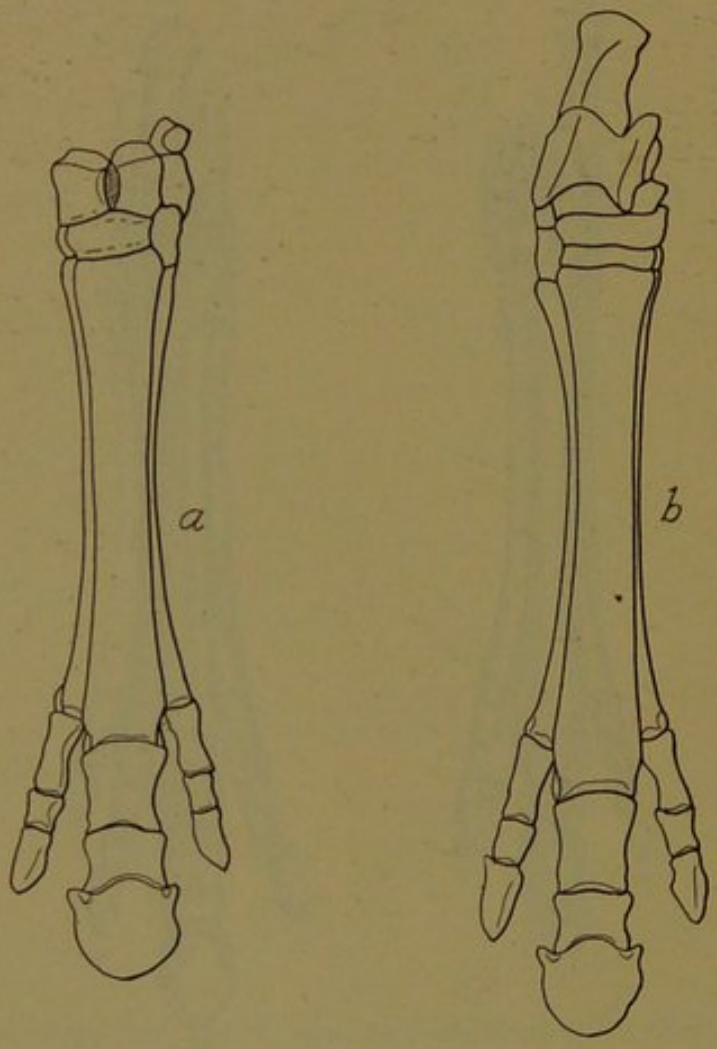

FIG. 11. *a*, Fore foot and *b*, hind foot of *Hypohippus equinus;* drawn from casts from the American Museum of Natural History. One-fourth natural size. (Original.)

Middle John Day (green beds), probably referable to *M. anceps.* The collection contains the fore and hind feet and numerous skeletal elements. The John Day types are confined to Oregon.

MIOCENE PERIOD.

This was a time of continental elevation and great expansion of our western prairies and a consequent diminution of the forest-clad areas. Many mammals otherwise well fitted for survival, such as the titanotheres whose remains are very numerous in the Oligocene beds, were unable to meet the new conditions because of their very perfect adaptation to softer herbage, and thus became extinct. This was also true of certain horses, such as *Hypohippus*, but the great majority were more plastic and in consequence underwent a remarkable development, during this period reaching the culmination in numbers and kinds.

Hypohippus has already been alluded to as one which became extinct during the Miocene, leaving no descendants. It is generally referred to as the "forest horse" from the broad low-crowned teeth fitted only for browsing upon succulent herbage, and from the character of the spreading three-toed feet in which the lateral digits still touch the ground. This would imply an animal fitted for soft ground rather than for speed over the dry prairie soil. The reindeer, whose home is on the mossy tundras, has a broad spreading foot with large lateral toes, while in the fleet-footed prong-horn antelope of our western plains the lateral hoofs have entirely disappeared.

In the hand of *Hypohippus* vestiges of digits one and five may still be seen as small nodules of bone at the back of the wrist. This would imply the descent of this genus from some undiscovered Oligocene ancestor, for in no known instance do we find traces of the first digit in a horse of that period. *Hypohippus* was a comparatively large horse for its time, being forty inches at the withers. It is an admirable example of arrested evolution. There are few specimens of this form in the Yale collection; hence it is represented in the series by a fore foot and lower jaw and by casts of the skull, jaws, and feet of a mounted specimen in the American Museum. *Hypohippus* has been found in the Loup Fork beds of Montana and South Dakota.

Merychippus is of especial interest and is in the direct line of descent, through some of its species giving rise to all subsequent Equidæ. It is three-toed, in some instances with vestiges of the outermost digits of the hand. Digits two and four vary somewhat in development in the different species, though never reaching the ground, so that the feet are functionally one-toed.

It is in the teeth that the greatest interest lies, for herein *Merychippus* is midway in the course of evolution, in the young condition having the short-crowned uncemented teeth

of its ancestors, while in the adult state the teeth are long-crowned and cemented as in its successors. The adult teeth are not very long, but are of the columnar or prismatic type and in some instances show a fair degree of complexity in the enamel pattern. *Merychippus* is also the first horse to complete the hinder border of the orbit by sending downward a bony bar to join the zygomatic arch. This bar is represented by a process in its predecessors. The genus ranged from Texas to Montana and Oregon, the Yale collection containing specimens from the Loup Fork deposits along the Niobrara River in Nebraska.

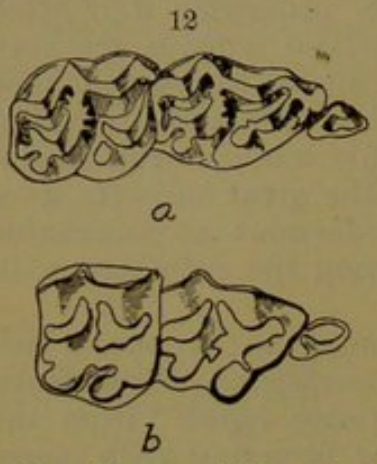

FIG. 12. *a*, Milk and *b*, permanent premolar teeth of *Merychippus insignis*. Two-thirds natural size. (Original.)

Protohippus of the Loup Fork beds is with difficulty distinguished from *Merychippus*, but has gone farther in that both milk and permanent teeth are fully cemented. The teeth are lengthened and are sharply curved, owing to the shallow depth of the jaws. *Protohippus* was still three-toed, but as far as known the vestiges of digits one and five in the hand have now entirely disappeared. This animal was about thirty-six inches in height at the shoulder and its distribution is similar to that of *Merychippus*.

Pliohippus is found in the Upper Loup Fork beds and ranges up into the Pliocene. It may have been a one-toed horse; for this we have Professor Marsh's authority, though later writers are not inclined to accept the evidence on this point as final. Certain it is that in the type specimen of *Pliohippus pernix* at Yale the lateral toes must have been extremely small, as the splint bones are not much more developed than in the modern horse. Unfortunately the lower ends of all the splints are missing, so that one cannot be sure whether or not they bore an articular extremity. The teeth of *Pliohippus* were larger than those of *Protohippus*, and in some instances still more sharply curved, but the enamel pattern was simpler, with large cement areas.

Pliohippus is the largest of the Loup Fork horses, being forty-eight inches at the withers as compared with sixty-four in a large modern horse. It may be in the direct line of descent to *Equus*, but of this we cannot be sure, as all the links in the chain of descent have not yet been found. Its geographical range covered the western United States, the Yale Museum specimens including the types of *Pliohippus pernix*, *P. robustus*, and *P. gracilis*, coming from Nebraska and

Oregon. The reference of *P. gracilis*, the Oregon specimen, to this genus seems somewhat questionable, as the splint bones are large rather than slender as in the typical species.

Contemporaneous with *Protohippus* and like it a descendant of *Merychippus* is *Neohipparion*, a three-toed horse with very complex teeth in which the anterior-internal column (protocone) is isolated from the anterior cross crest (protoloph), not

13

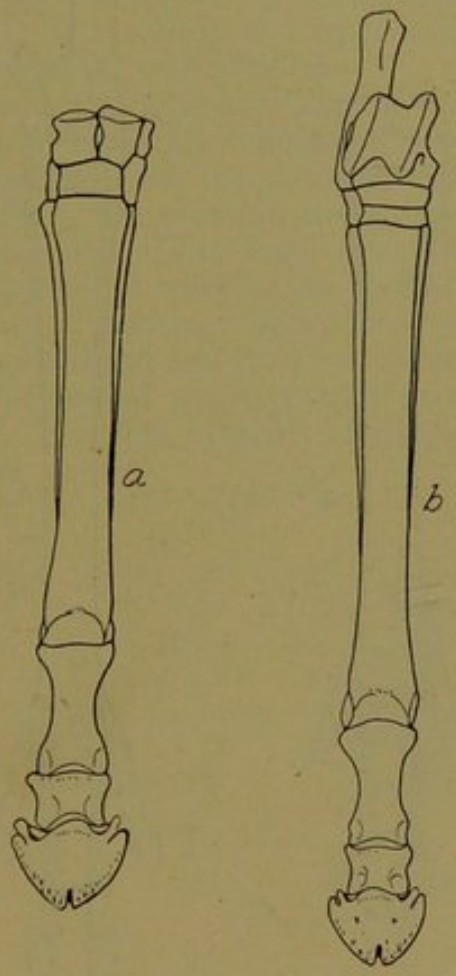

FIG. 13. *a*, Fore foot and *b*, hind foot of *Pliohippus pernix;* drawn from the type specimen, No. 11376, Yale University Museum. One-fourth natural size. (Original.)

connected with it as in all other horses. One can trace the evolution of this feature, for in *Merychippus insignis* the protocone, while attached, tends to become free, yet in *Neohipparion isonesum* the reverse is true in that the protocone, though free, shows a strong reluctance to leave its old association with the anterior crest. In other species of *Neohipparion* this is not apparent, the protocone being oval in

section and entirely free in all stages of wear. *Neohipparion* is abundantly represented in the Yale collections, was about forty inches in height at the shoulder, of deerlike aspect, and like the deer admirably adapted for speed.

In the Old World this horse is represented by its descendant *Hipparion*, ranging from the Pikermi beds, which are of

14

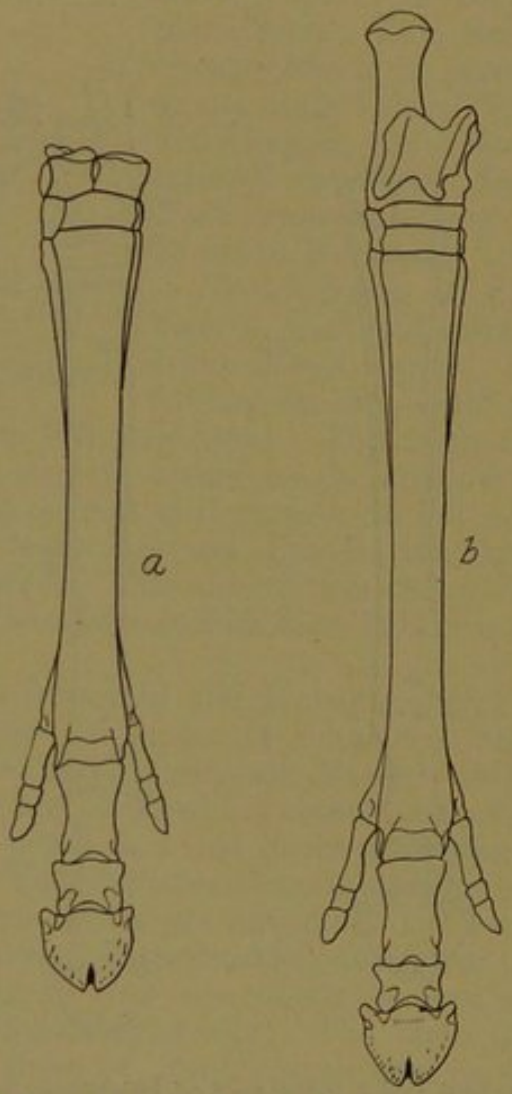

FIG. 14. *a*, Fore foot and *b*, hind foot of *Neohipparion whitneyi;* drawn from casts from the American Museum of Natural History. *Protohippus* is in the same stage of evolution. One-fourth natural size. (Original.)

equivalent age with the Upper Loup Fork, to the Middle Pliocene. *Hipparion gracile*, found in Greece, is also a three-toed horse, though much larger than its American progenitors. This species is represented in the Yale collection by an admirable skull, jaw, and feet and limb bones, from the Museum of the University of Athens.

PLIOCENE PERIOD.

It is probable that the later species of *Pliohippus* were Pliocene in distribution; certainly *Hipparion* of the Old World was, while during this period the true one-toed horses, *Equus* and the curious South American *Hippidion*, first appear. The latter is supposed by some to be a descendant of *Pliohippus*, but this is a matter of doubt. In the Siwalik beds of India is found a one-toed *Hipparion*, and it has been suggested that the modern zebras may be the living descendants of this genus. It is certainly not in the line to the common horse, *Equus caballus*.

15

FIG. 15. Upper molar tooth of *Neohipparion affine* Leidy; *pr*, protocone. Two-thirds natural size. (Original.)

Hippidion was extremely short-legged, with a large head and curiously elongated nasal bones, which together with the position of the eyes must have given the creature a very peculiar cast of countenance. The teeth resembled those of *Pliohippus* but were larger and of a more intricate enamel pattern. *Hippidion* was evidently much specialized and does not seem to have survived the time of the deposition of the Pampas beds in Ecuador, Brazil, Bolivia, and Argentina, where it is found.

16

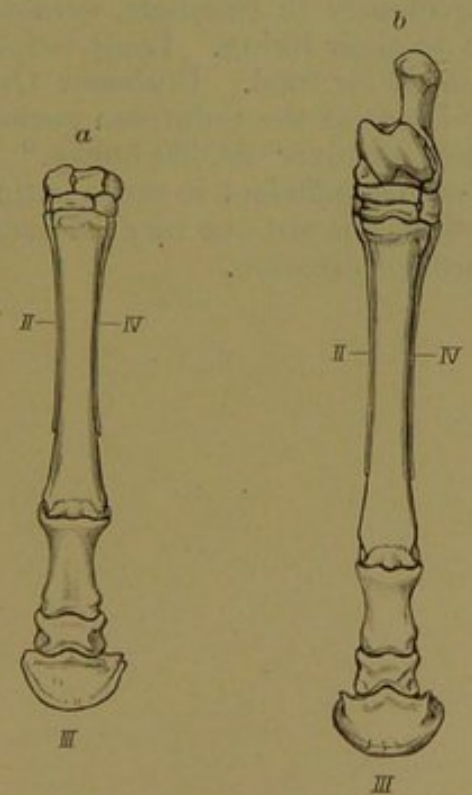

FIG. 16. *a*, Fore foot and *b*, hind foot of *Equus caballus*. One-eighth natural size. (After Marsh.)

Equus, the modern horse, first appears in the Upper Pliocene beds of Eurasia and North America, and represents the culmination of the race. The feet are one-toed but with well-developed splints of the second and fourth digits still remaining. These are sometimes fused with the adjoining canon bone; sometimes they are free, but only in the rare cases of reversion do they bear any traces of the lateral toes. The teeth are long columnar structures of intricate enamel pattern, admirably suited to their owner's needs, while the animal has attained the maximum stature consistent with fleetness.

Fossil members of this genus are very widespread, yet the existing species are entirely confined to Asia and Africa. In North America many fossil species have been described, though reduced to nine by Gidley; in point of tooth structure, one of these, *Equus fraternus*, resembles closely the modern horse, *E. caballus*. *E. giganteus* from southwestern Texas was evidently of great size, "the teeth exceeding those of the largest modern draught horses by more than one-third the diameter of the latter" (Gidley).

In spite of perfection of adaptation the American horses became entirely extinct before the discovery of America by Europeans. This is all the more remarkable in view of the fact that conditions in our West are such that the few horses which escaped from the Spanish explorers have increased so marvelously in numbers, evidently finding these conditions much to their liking. Long before domestication the horse was hunted for food. Professor Osborn states that "one of the bone heaps of the Solutréen period is estimated to include the remains of over 80,000 horses." Even this great slaughter would not be sufficient to cause extinction, for before the invention of fire-arms not one race of large mammals succumbed to the lords of creation.