

people visited, icebergs, corals and coral reefs, the habits and nature of some of the stranger animals and plants of the sea and land, and on geological, anthropological and other topics; and they are presented in the direct and lucid style that bespeaks the faithful scientific observer. The author is an able naturalist, and has published many very valuable papers (partly in the Transactions of the Royal Society) as the results of careful work during the cruise and of thorough microscopic investigations since, relating to the structure of *Millepores*, the Aleyonarian relations and structure of *Heliopora cœrulea*, the structure of the *Stylasteridae*, on *Corals*, *Actinaria*, *Planarice*, and other zoological subjects, besides Botanical notes in the Journal of the Linnæan Society.

3. *Report of the National Academy of Sciences*.—At the meeting of the National Academy of Sciences held in Washington, April 15th to 19th, 1879, the following papers were read:

C. S. PEIRCE.—Ghosts in the diffraction spectra; Comparisons of the meter with wave lengths; On the errors of pendulum experiments, and on the method of swinging pendulums proposed by Mr. Faye; On projections of the sphere which preserve the angles.

HENRY DRAPER.—Confirmations by spectrum photographs of the discovery of oxygen in the sun.

E. C. PICKERING.—On the eclipses of Jupiter's satellites; On two new forms of micrometers.

ALFRED M. MAYER.—On a new form of heliostat.

J. E. HILGARD.—Report on the progress of the international bureau of weights and measures; An account of geodetic acts determined by the Coast Survey in relation to the figure of the earth.

SIMON NEWCOMB.—On the recurrence of solar eclipses.

H. A. NEWTON.—On the influence of Jupiter upon bodies passing near that planet.

S. WEIR MITCHELL.—On the relations of neuralgic pains to storms and the earth's magnetism.

C. F. CHANDLER.—On a new polariscopic method for the detection and estimation of dextro-glucose in the presence of cane sugar and inverted sugars.

H. L. ABBOTT.—On the ignition of high tension fuses.

ELIAS LOOMIS.—The winds on Mount Washington compared with the winds near the level of the sea.

E. W. HILGARD.—The loss of the Mississippi, and the Æolian hypothesis.

JOSEPH LeCONTE.—The extinct volcanoes about Lake Mono and their relation to our glacial drift.

J. S. NEWBERRY.—On the great silver deposits recently discovered in Colorado, Utah, and Nevada.

G. J. BRUSH.—On a mineral locality in Fairfield County, Connecticut.

A. AGASSIZ.—Report on dredgings in the Caribbean Sea by the Coast Survey steamer Blake, Commander John R. Bartlett, United States Navy.

C. V. RILEY.—On the hibernations and migrations of *Aletia argillacea* (the parent of the cotton-worm).

S. H. SCUDDER.—The Palæozoic cockroaches.

E. D. COPE.—On the extinct species of the Rhinoceros and allied forms of North America.

H. MITCHELL.—On the physical hydrography of the Gulf of Maine.

G. K. GILBERT.—On the stability and instability of drainage lines.

A. GRAHAM BELL.—On vowel theories considered in the light of recent experiments with the phonograph and phonautograph.

F. A. P. BARNARD.—Report of the Committee on Weights, Measures, and Coinage.

Professor William B. Rogers was elected President in place of Joseph Henry, deceased. The following new members were elected: Cleveland Abbe, J. W. Gibbs, W. G. Farlow, H. C. Wood.

APPENDIX.

1879

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ART. LXIII.—*Polydactyle Horses, Recent and Extinct*; by Professor O. C. MARSH.

It is said that the aborigines of this country, when they first saw the horses brought over by the Spaniards, named the new animal "the beast with one finger nail." Certainly, the single hoof on each foot is the most marked characteristic of the modern horse, and one on which some of his most valuable qualities depend. The nearest living allies of the horse are the ass and the zebra, and they possess the same pedal peculiarities.

In addition to each main digit of the ordinary horse, however, the anatomist finds concealed beneath the skin two slender metapodial "splint bones," which are evidently the remnants of two other toes, originally possessed by the ancestors of the horse. It is an interesting fact that these splint bones are sometimes quite fully developed, and may even support extra digits, which are much smaller and shorter than the main foot. As these small hooflets are usually regarded as a serious detriment to the animal, they are generally removed from the colt soon after birth, but in such cases the enlarged splint bones not unfrequently indicate in the adult their former existence.

Numerous cases of extra digits in the horse have been recorded, and in nearly all of them a single lateral hooflet was present on one of the fore legs. In most instances the occurrence was noted chiefly on account of its rarity, and no record was made of the exact position of the extra hoofs with reference to the main digit, nor of the significance of these useless appendages. Since the attention of the writer was called to the subject, a few years since, he has ascertained that these supernumerary digits are much more common in the horse than has been supposed, and in many cases they appear to indicate a reversion to an early ancestral type.

The figures given below represent, (1) the foot of the modern horse in its normal condition, with the splint bones rudimentary; (2) the foot abnormally developed, with one splint bone bearing a small hooflet; and (3) the foot of an extinct three-toed ancestor of the horse. The feet are all from the left side, and the numbers attached indicate the different digits, counting from the inside. The first and fifth, corresponding to the thumb and little finger of the human hand, are wanting in these figures. A specimen similar to that represented in figure 2 is preserved in the Museum of Yale College.

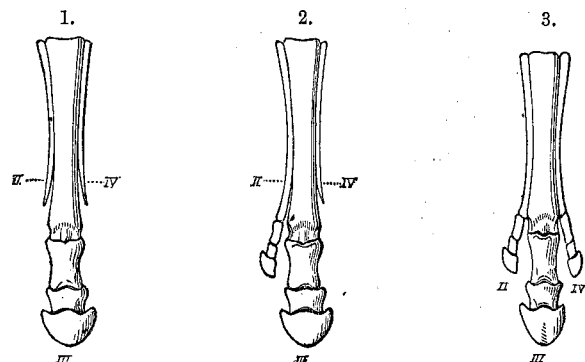


Figure 1.—Fore foot of Horse (*Equus*).
Figure 2.—Fore foot of Horse with extra digit.
Figure 3.—Fore foot of *Hipparion*.

The first recorded instances of extra digits in the horse, known to the writer, are two mentioned by George Simon Winter, in his famous book on Horses, published near the beginning of the last century.* One of the horses referred to and figured in this work was "eight-toed," having a small extra digit on the inside of each foot (p. 134, Plate 21 F.). Winter states that this horse was exhibited in Germany in 1663, and a portrait of it preserved in Cologne. His account was derived from a person who had examined the animal. The other horse described by Winter (page 136, Plate 24), had a small hoof on the inside of each fore foot, and this steed, Winter states, he had not only seen but ridden.

Geoffroy Saint-Hilaire has recorded the fact that he examined a foetal horse which was polydactyle on the fore feet, the left foot bearing three nearly equal digits, and the right but two.† Owen has described the right fore foot of a horse with a double hoof, the extra digit being on the inner side, answering to

* *De Re Equaria*, Nuremberg, 1703.

† *Annales des Sciences Naturelles*, XI, p. 224. Paris, 1827.

the second digit.* Arloing has figured and described similar specimens.† Leidy has described the right fore leg of a horse with a supernumerary digit on the inner side; and Allen subsequently discussed the same specimen.‡ A number of other instances have been recorded, showing that extra digits are by no means rare in the modern horse.

The most interesting case of this kind examined personally by the writer is the horse represented in figure 4. This animal was on exhibition in New Orleans, in the spring of 1878, and Dr. Stanford E. Chaillé of that city first called the attention of the writer to it, and likewise sent a photograph, from which the cut below was made.

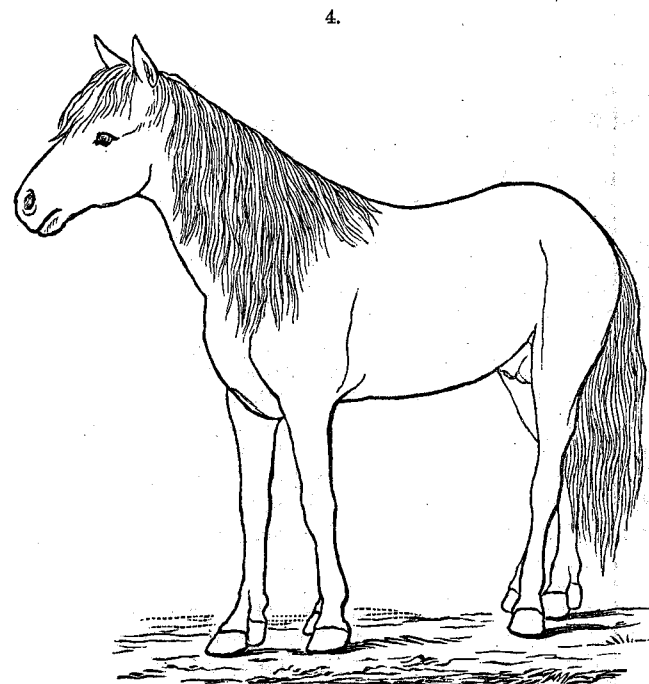


Figure 4.—Outline of horse with extra digit on each foot.

This same horse was subsequently brought to the North, and a few days since was on exhibition in New Haven, Conn., where the writer examined him with some care. The animal is of small size, about ten years old, and is said to have been foaled

* *Osteological Catalogue*, Museum Royal College of Surgeons, Vol. II, p. 537. London, 1853.

† *Annales des Sciences Naturelles*, VIII, p. 55. 1867.

‡ *Proceedings Academy Natural Sciences*, Philadelphia. 1871, p. 112, and 1876, p. 92.

in Cuba. He is known among showmen as the "Eight-footed Cuban Horse." With the exception of the extra digits, he is well-formed, and doubtless is capable of considerable speed, although some of the exploits claimed for him may fairly be questioned.

The four main hoofs are of the ordinary form and size. The extra digits are all on the inside, and correspond to the index finger of the human hand. They are less than half the size of the principal toes, and none of them reach the ground. An external examination indicates that the metapodial bone of each extra digit is entire, and at its lower end, at least, is not coössified with the main cannon bone.

There appear to be two phalanges above the coffin bone in each of these digits, which are thus rendered flexible, especially in a fore and aft direction. There was no indication of "interfering" shown on the inner digits themselves, although it is difficult to see how this could be entirely avoided during rapid motion. The splint bone on the outer side of each leg is apparently of the usual shape and size.

Among the instances of recent polydactyle horses, described to the writer by those who have seen them, are two of special interest. One of these was a colt with three toes on one fore foot, and two on the other. The animal recently died in Ohio. Another is a mare, raised in Indiana, and still living, which is said to have three toes on each fore foot, and a small extra digit on each hind foot. In regard to the latter animal, the writer hopes soon to have more definite information.

Besides the instances mentioned above of extra digits in place in the existing horse, there are many cases on record of true monstrosities, as, for example, additional feet or limbs attached to various portions of the body. Such deformities now admit of classification and explanation, but need not be considered in the present discussion.

In reviewing what is now known of extra digits in the feet of the modern horse, the best authenticated instances appear to fall naturally into two groups. The first of these includes digits which are simply cases of reduplication, quite similar to the extra finger occasionally seen in the human hand. Such deformities are apparently a vegetative repetition, the explanation of which has not yet been satisfactorily determined. The second class includes cases where a true digit is formed, the component bones of which are in their normal position, and in proper relation to the rest of the limb. Such instances appear to be clearly due to reversion to some ancestral type. Some digits, which appear at first sight to belong in the first category, may really illustrate the second, but the converse of this is

much less likely to be true. The cases of apparent reversion are of especial interest, and it is important to place on record any information in regard to them, so that they may be compared with extinct allies of the horse.

The cases of extra digits in the horse, so far as at present known, show that these appendages make their appearance more frequently on the fore feet than on the hind feet. This is precisely what a study of the fossil forms of equine mammals would lead us to anticipate.

Another noticeable peculiarity of these extra digits, is their more frequent occurrence on the inside of the main digit, while the outer splint remains rudimentary. This, it must be confessed, is directly opposed to the general law of reduction in the ungulate foot, which, briefly stated, is, that of the five original digits, the first or inner one, first disappears; next the fifth, or outer one; then, the second; and last of all the fourth. The third always remains, as in the horse. It would, therefore, be naturally expected, that when only one additional digit was present, it would be on the outside of the fore foot.

The tendency to interference would seem to be another reason against the retention of the inner digit. Possibly the additional protection which an inside hooflet would receive, might more than counterbalance this influence. Again, the above law is not known to apply to the perissodactyle foot, beyond the first and fifth digits, and if the second digit was originally of greater use than the fourth, and hence was longer retained, an ancestor of the horse may yet be found with the second and third toes alone developed.

In considering these double hoofs of the horse, and with them the well known cleft in the coffin bone of recent and extinct equines, it is important to understand that in no case do they indicate any approach to the true artiodactyle type, as some authors have supposed. The difference between the perissodactyle, or "odd-toed," and artiodactyle, or "even-toed," structure is a profound one, extending to nearly every part of the skeleton, and marking two distinct groups of Ungulates. The number of toes has really nothing to do with the true distinction, and hence the terms in use are especially misleading. The real difference, so far as the feet are concerned, is, that in the perissodactyle type the axis of the limb passes through the middle of the third digit (*Mesaxonia*), while in artiodactyles it is outside of this digit (*Paraxonia*), between it and the fourth.

If, now, we turn back to the early ancestors of the horse, for an explanation of the supplementary digits which so often make their appearance, we shall not look in vain, especially in this country. America is the original home of the horse, and

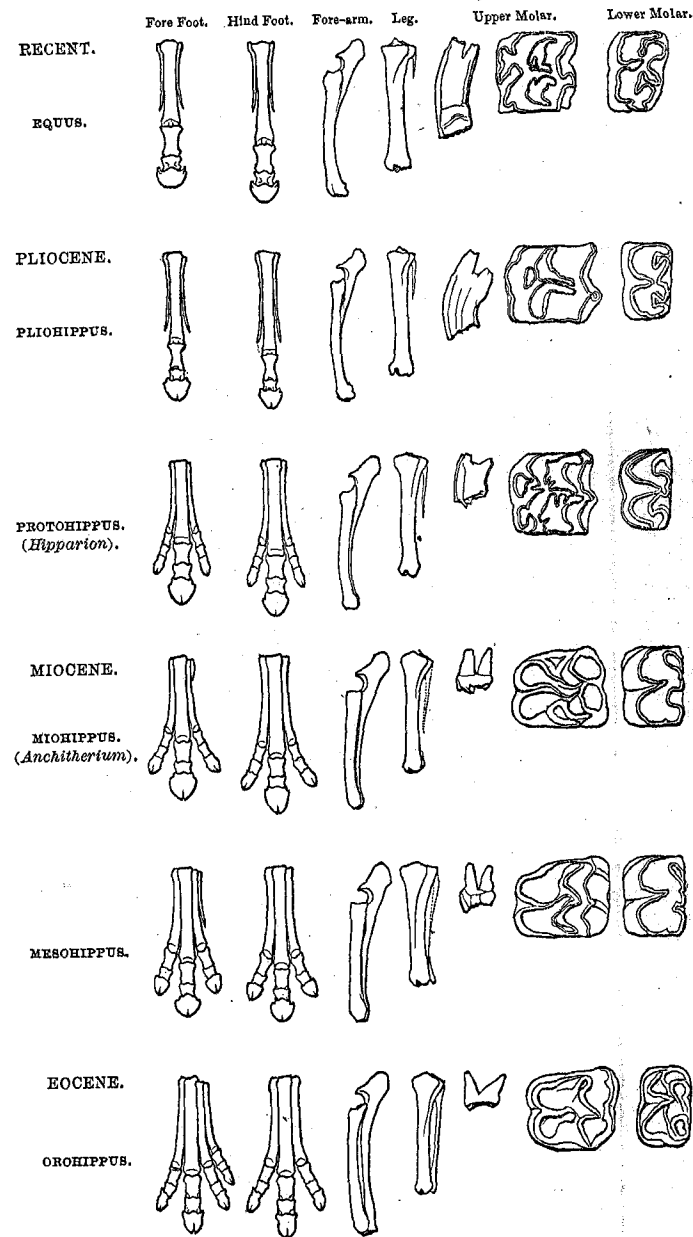
during the whole of Tertiary time, this continent was occupied with equine mammals, of many and various forms. Although all these became extinct before the discovery of this country, their abundant remains mark out the genealogy of the horse in an almost unbroken succession of forms.

If we examine the remains of the oldest representatives of the horse in this country, we shall find that these animals were all polydactyle, and of small size. As the line was continued towards the present era, there was a gradual increase in size, and a diminution in the number of toes, until the present type of horse was produced. In view of the facts mentioned in the preceding pages, it will be profitable to trace the main line of descent in this group, from its first appearance to the present period, and note especially the changes in the number of digits. For this purpose the diagram on page 505 will be instructive, as it records the principal stages in the series, both of the limbs and the teeth as well. This diagram was prepared by the writer for Professor Huxley, who used it first in his New York lectures. The specimens figured are all in the Yale Museum.

The original ancestor of the horse, not as yet discovered, undoubtedly had five toes on each foot. The oldest member of the group now known is the *Eohippus*, which had four well developed toes and the rudiment of another on each fore foot, and three toes behind. This animal was about as large as a fox, and its remains are from the Coryphodon beds, near the base of the Eocene. It is not represented on page 505, as it was found since the diagram was made. In the next higher division of the Eocene, another equine genus, *Orohippus*, makes its appearance. It resembled its predecessor in size, but had only four toes in front and three behind, as shown in the lowest series of the diagram. At the top of the Eocene, a third allied genus has been found (*Epihippus*), which closely resembled *Orohippus* in its digits, but differed in its teeth.

Near the base of the next formation, the Miocene, another equine mammal, *Mesohippus*, occurs. This animal was about as large as a sheep, and had three usable toes and the splint of another, on each fore foot, with but three toes behind, as shown in the diagram. At a somewhat higher horizon, a nearly allied genus, *Miohippus*, has been found, which has the splint bone of the outer or fifth digit reduced to a short remnant. In the Pliocene above, a three toed horse (*Protohippus*) about as large as a donkey was abundant, and still higher up a near ally of the modern horse, with only a single toe on each foot, (*Pliohippus*) makes his appearance. A true *Equus*, as large as the existing horse, appears just above this horizon, and the series is complete.

Yale College, New Haven, May 15th, 1879.



GENEALOGY OF THE HORSE.