item of the journey. In these later years, when amateur travel in the west is frequent, a detailed record of this kind will be of value to seekers after adventure; even if certain parts of the river are unduly dangerous, there are other long stretches in which a boat trip might well be undertaken in a summer vacation without too great disregard of a safe return home. Whether made by scientist, hunter or artist, the journey would surely be repaying in high degree, as one may be assured from the plates, as well as from Dellenbaugh's vivid descriptions. The solitude must be impressive as one floats down the smooth reaches beneath a mighty architecture of bare cliffs. The excitement of running rapids would seem to be sufficient for the most ardent seeker of new impressions. Many of the plates are excellent, although reproduced from photographs taken nearly forty years ago.

W. M. D.

SPECIAL ARTICLES

THE POSSIBLE ANCESTORS OF THE HORSES LIVING UNDER DOMESTICATION[1]

DURING the later part of the nineteenth century, it was generally taken for granted (1) that "the seven or eight species of Equidæ now existing are all descended from an ancestor of a dun colour more or less striped";[2] (2) that the common ancestor of the living horses, asses and zebras was connected by a single line of descent with the four-toed "fossil" horses of the Eocene period; (3) that the domestic horses are descended from Pleistocene species characterized by large molars with a long anterior internal pillar, a large heavy head and coarse limbs; (4) that in various parts of Europe and Asia, domestic races increased in size and were improved in make, speed and disposition, as a result of artificial selection and favorable surroundings.

On the continent it seems to be still generally assumed that the domestic breeds have descended from a single species,[3] but in England and America many naturalists now believe: (1) That domestic horses have sprung from several wild species connected by several lines of descent with the three-hoofed "fossil horses" of the Miocene period, and (2) that while some of the wild ancestors were adapted for living in the vicinity of forests and upland valleys, others were adapted for a steppe, plateau or desert life.

Of possible ancestors of the domestic breeds, the following may be mentioned: *Equus sivalensis, E. stenonis, E. gracilis* (Owen's *Asinus fossilis*), *E. namadicus*,[4] *E. fossilis* and *E. robustus*.

These species mainly differ in the teeth, size and deflection of the face and in the bones of the limbs. In the first three species the grinding surface of the anterior internal pillar (a fold of enamel on the inner surface of the cheek teeth) of the premolars and first molar, is short—in the last premolar, pm. 4, it may only be one third the length of the crown—in the second three species the anterior internal pillar of pm. 4 and m. 1, is long—at least half the antero-posterior length of the crown. One of the ancestral types (*E. robustus*) was broad-browed and had a short face almost in a line with the cranium; another (*E. sivalensis*), also broad-browed, had a long tapering, strongly deflected face; a third (*E. fossilis*) had a long narrow face, not so strongly bent downwards as in *E. sivalensis*, and a fourth (*E. gracilis*) had a fine narrow, but only slightly deflected, face.

In *E. gracilis* the middle metacarpal (cannon bone) was so slender that the length was seven and a half times the width, while in *E. robustus* the length of the metacarpal was sometimes only five and a half times the width.

Of these possible ancestors, the first three occur in Pliocene deposits, the second three have only hitherto been found in Pleistocene deposits.

[1] Abstract of a paper presented to the Royal Society, London.

[2] Darwin, "Animals and Plants," Vol. II., p. 17.

[3] The latest suggestion is that domestic horses are the descendants of *Equus fossilis* Rütimeyer, a Pleistocene species closely allied to the wild horse of Mongolia—*E. przewalskii*.

[4] *E. namadicus* seems to be closely allied to *E. complicatus*, a species widely distributed in North America during the Pleistocene period.

Equus sivalensis of the Siwalik deposits of northern India is the oldest true horse known to science (*i. e.,* the oldest one-hoofed horse with long (hypsodont) molars), and as it measured about fifteen hands, it is the largest of the old world "fossil" horses. This ancient Siwalik horse was characterized by long, fairly slender limbs and a long tapering face deflected to form an angle of nearly 20° with the base of the cranium. In addition to having a large head, a convex profile and long limbs, *E. sivalensis* seems to have been characterized by a long neck, high withers and a tail set on so high that the root was well in front of the point of the buttock.

Nothing is known of the ancestors of the horse which suddenly made its appearance in Pliocene times amongst the foothills of the Himalayas, but it may be safely assumed that it very decidedly differed from *Pliohippus,* the small "fossil" horse of the late Miocene and early Pliocene deposits of America from which some believe all the recent Equidæ are descended.

It used to be said that *E. sivalensis* could not be regarded as an ancestor of domestic horses because of the shortness of the anterior pillar of the cheek teeth. I find, however, that in some modern horses, the anterior pillars are decidedly shorter than in *E. sivalensis,* and that in some of the short-pillared domestic horses the face is nearly as strongly deflected on the cranium as in *E. sivalensis.* There is hence no longer any reason for assuming that this ancient Indian species had no share in the making of domestic breeds. But in the absence of a large and representative collection of skulls of domestic horses, it is impossible to say which modern breeds are most indebted to the large-headed, long-limbed race, which in Pliocene times frequented the area to the east of the Jhelum River, now occupied by the Siwalik Hills.

Mr. Lydekker thinks *E. sivalensis* or some closely allied race "may have been the ancestral stock from which Barbs, Arabs and Thoroughbreds are derived." When more skulls are available for study and when the phases through which equine skulls pass during development and growth have been worked out, it will probably be ascertained that broad-browed horses with a prominent interorbital region—a forehead convex from side to side as well as from above downwards—and a long tapering strongly deflected face have in great part descended from a species closely allied to *E. sivalensis,* but that slender-limbed horses with a broad flat forehead, and the face short and nearly in a line with the cranium, are at the most only remotely related to *E. sivalensis.*

Further enquiries will probably also show that some Indian breeds, as well as some of the unimproved races of Central Asia (*e. g.,* certain long-faced Kirghiz horses with a sloping forehead and long ears) in many of the points agree with *E. sivalensis* of the Pliocene deposits of northern India.

The second possible ancestor mentioned is *Equus stenonis* of the Pliocene deposits of Europe and North Africa. In a typical specimen of this species with the teeth in an intermediate state of wear, all the anterior pillars of the premolars and molars are shorter than in *E. sivalensis,* while in a specimen with the teeth well worn, the longest pillar may be only one third the length of the grinding surface of the crown—at no age are the pillars of the molars more than half the length of the crown. Whether the face was long and tapering and strongly deflected in *E. stenonis* has not yet been determined, but from the limb bones collected, it is evident that the horse with short-pillared molars, which in Pliocene times frequented the valley of the Arno, sometimes reached a height of nearly fifteen hands.

It is generally supposed *E. stenonis* either became extinct towards the close of the Pliocene age or was modified to form varieties with long-pillared molars. It is conceivable that some of the descendants of *E. stenonis* acquired long-pillared molars, but it by no means follows that all the Pleistocene horses of Europe with the anterior pillars more than half the length of the crown are related to or derived from *E. stenonis*—some of them may have been the descendants of *E. namadicus.*

Be this as it may, horses with teeth of the *E. stenonis* type existed in the south of Scotland during the first and second centuries, and horses with short-pillared cheek teeth are still in existence. In some of the skulls from the Roman fort at Newstead, the anterior pillar of the third and fourth premolars only measures 9 mm.—is only about half the length of the pillar in *E. namadicus* and other "fossil" Pleistocene species. Further, in one of the first century Newstead skulls, the first premolar is as large as in *E. stenonis,* and the face (as broad and long as in *E. sivalensis*) forms an angle of 18° 6′ with the cranium.

Further enquiries may show that the short-pillared species (with metacarpals as long but somewhat thicker than in *E. sivalensis*) widely distributed over Europe and north Africa, in Pliocene times played an important part in the making of Shires and other heavy modern breeds.

The only other possible ancestor dealt with in this contribution is the one to which I have given the name *Equus gracilis.*

Owen arrived at the conclusion that Pleistocene horses "had a larger head than the domesticated races" and that even in small varieties the teeth were nearly as large as in a modern cart horse.

Having come to these conclusions it is not surprising that when it fell to his lot to describe small equine molars from the drift overlying the London Clay and from a cavernous fissure at Oroston, near Plymouth, he decided that they could not belong to a true horse and (on the assumption that they belonged to an extinct ass or zebra) formed for them the species *Asinus fossilis.* In addition to the small second and third molars described and figured by Owen, there is in the British Museum a small first molar from Oreston. The anterior pillars of the second and third Oreston molars are more than half the length of the crown, as in horses of "forest" type, but the pillar of the first molar, m. 1, from Oreston is only about one third the length of the crown, as in *Pliohippus* and *E. stenonis.* Except in size, the small teeth from Oreston and other Pleistocene deposits bear little resemblance to the molars of asses or zebras, but they are practically identical in enamel foldings, as well as in size, with the molars of a small (12.2 hands) slender-limbed horse in the possession of the Auxiliaries who garrisoned the Roman fort at Newstead in the south of Scotland about the end of the first century.

In addition to small equine teeth the Devonshire Pleistocene deposits have yielded a small slender metacarpal. This metacarpal (from Kent's Cave near Torquay) is 220 mm. long and 30.25 mm. wide—the length is hence 7.27 times the width, as in fine-boned Arabs.

As might have been anticipated from a study of the teeth, the Kent's Cave metacarpal belongs to a very much finer-limbed race, than the small horse of the "elephant" bed at Brighton. On the other hand, the Kent's Cave metacarpal very closely agrees with the metacarpals of the small Newstead horse. This small first century horse in teeth and limbs agrees with Exmoor, Hebridean and other ponies of the "Celtic" type, *i. e.,* with ponies characterized by a small fine head, large eyes, slender limbs, five lumbar vertebræ and by the absence of the hind chestnuts and all four ergots.

It hence follows that the small equine of the English Pleistocene (Owen's *Asinus fossilis*) instead of being an ass or a zebra, is a true horse which in the metacarpals as in the "pillars" of the premolars and first molar, differs but little from *Pliohippus* of the late Miocene and early Pliocene American deposits.

Remains of a small horse with teeth and limbs like *Equus gracilis* (*Asinus fossilis* Owen) have been found in the Pliocene deposits of Italy and France, and in the Pleistocene deposits of France and north Africa. The Italian and Auvergne slender-limbed horse has generally been regarded as a small variety of *E. stenonis.* By Pomel and other paleontologists this French variety was known as *E. ligeris,* while the north African variety, named *Equus asinus atlanticus* by Thomas, was regarded by M. Boule as closely allied to, if not the ancestor of zebras of the Burchell type.

The slender metacarpals from the valley of the Arno and Auvergne so closely resemble the Kent's Cave metacarpal and the teeth from Perrier and Puy de Dôme in France and Lake Karar in Algiers so closely resemble the small teeth from Oreston, that *E. ligeris* and *E. asinus atlanticus* may be regarded as varieties or races of *E. gracilis*.

There are good reasons for believing that *E. gracilis* varied to form a northern and a southern variety. Remains of a slender-limbed northern race have been found in deposits belonging to the Neolithic, Bronze and still later ages in Britain and on the continent. At the present day the purest representative of this northern variety is the "Celtic" pony. Hence this northern variety may be known as *Equus gracilis celticus*.

Remains of a slender-limbed southern variety have not yet been found in recent deposits in north Africa, but fine-limbed ponies without ergots and hind chestnuts are sometimes met with in the south of France, and slender-limbed horses without hind chestnuts —horses almost certainly of north African descent—are occasionally met with in the West Indies and Mexico. In the French and still more in the wartless ponies of Mexico the limbs are longer than in the Celtic ponies, the coat is finer, the mane less full and the "tail-lock," so well developed in the northern variety, is very small. As the southern variety in all essential points agrees with Professor Ridgeway's fine bay horse of north Africa (*E. caballus libycus*) it may be known as *E. gracilis libycus*.

Slender limbs and the absence of ergots and hind chestnuts, are apparently as distinctive of members of *E. gracilis* as an upright mane and the absence of hind chestnuts are distinctive of asses and zebras. Hence when as a result of crossing slender-limbed individuals without ergots and hind chestnuts appear in any area it may be assumed that the horses of that area include *E. gracilis* amongst their ancestors.

From enquiries made and from crossing experiments, it has been ascertained that ponies of the "Celtic" type occur in the Färöe Islands and Iceland, in the western islands and highlands of Scotland, in the west of Ireland, in Wales, Exmoor and the New Forest and in Norway and Finland.

Further crossing experiments have made it evident that the yellow-dun fjord horses of Norway are mainly a blend of the "Celtic" and "forest" types, that the Shetland ponies, though usually having the conformation of the "forest" or *E. robustus* type, are in part of Celtic origin, and that some of the mouse-dun Tarpans of the Russian steppes are a nearly equal blend of the Celtic and *E. przewalkii* or "steppe" types.

Professor Ridgeway arrived at the conclusion that in the fine bay horse of North Africa there is a frequent tendency to stripes on the back, legs, shoulders and face, to a blaze on the forehead and to white "bracelets." Experiments made with four types of Arabs and with Russian, Mongolian, Indian and Borneo ponies, English, Irish, Iceland and Norse ponies, support the view that the Pleistocene ancestors of the modern slender-limbed ponies with short-pillared molars was of a yellow or bay-dun color with a narrow dorsal band and bars on the legs, but had neither "bracelets" nor a blaze.

As stripes are most numerous on broad-browed horses with coarse limbs, they have probably in most cases been inherited from ancestors of the "forest" or *E. robustus* type.

As to the part played by *E. gracilis libycus* in forming domestic breeds, nothing very definite has been made out. Professor Ridgeway says all the improved breeds of the world are a blend in varying degrees of the bay horse of North Africa with thick-set, slow, dun and white horses of Europe and Asia allied to *E. przewalskii*. A number of hybrids bred at Woburn by the Duke of Bedford afford little, if any, evidence in support of the view that Barbs, Arabs or thoroughbreds include amongs their ancestors horses of the Prejvalsky or "steppe" type. Slender-limbed horses with a wide flat forehead and a nearly straight profile appear to be a blend of *E. gracilis libycus* (Ridgeway's *E. caballus libycus*) and horses of the *E. robustus* ("forest")

type, while slender-limbed strains with a fine narrow face, a well set-on tail and a mane that clings to the neck, probably most accurately reproduce the variety of *E. gracilis* which in prehistoric times inhabited north Africa.

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THE SOCIETY OF AMERICAN BACTERIOLOGISTS[1]

The Etiology of Plant Tumors: ERWIN F. SMITH. (Illustrated by numerous stereopticon photographs.)

The author prefaced his remarks with the statement that Dr. C. O. Townsend and Miss Nellie Brown were associated with him in the prosecution of this research. The address consisted of a series of lantern slides with running comment. The slides showed inoculated plants of various species and of widely different families, the growths in all cases being the result of pure culture inoculations of the schizomycete *Bacterium tumefaciens*. The crown gall of cultivated plants is cross inoculable to an astonishing degree. In susceptible tissues the signs of these galls appear within as short a time as four or five days. The tumor continues to grow for several months and in some cases for several years and may become 5 cm. or more in diameter. Hundreds of pure culture inoculations have been made. The organism cultivated from the Paris daisy has been inoculated many times successfully into the same and also into the peach, rose, hop, sugar-beet, white poplar and other susceptible plants. That from the crown gall of the peach has been many times successfully inoculated into the peach, and also into the Paris daisy, sugar-beet, hop and other plants. The schizomycete from the hop has been inoculated successfully into the hop and into the Paris daisy, sugar-beet and other plants. One of the astonishing things about this crown-gall organism is the number of families which are subject to infection; in other words, the very simple and generalized nutritional needs of the parasite. In some ways it resembles the root-tubercle organism of Leguminosæ, but is not identical. It has been inoculated into clovers with the production of knots. Quite recently from the hard gall of the apple (selected by Dr. Hedgcock) we have isolated an organism which appears to be like that occurring in other crown galls, and with this, hard galls have been produced upon the Paris daisy. A similar if not identical organism has also been isolated from the hairy root of the apple and successfully inoculated into the sugar-beet, *i. e.*, with the production of similar root-tufts at the point of inoculation. There is now little doubt, therefore, that the hairy root of the apple is also of bacterial origin.

Metastatic growths occur on these plants, but up to this time we have not definitely determined the channels of infection from the primary tumor to the secondary ones. These are easily discovered in the case of the olive-tubercle, but are not readily found in case of these crown galls. The same remark is true respecting the bacteria in the primary tumors. They are very abundant and easily discovered in the olive-tubercle, but not readily detected in the crown gall, although obtainable therefrom in Petri dish cultures on agar. It is still too early in the course of our studies to make positive statements respecting the likeness or unlikeness of these growths to malignant animal tumors, but it is proposed to continue this phase of the inquiry. There is in these growths a very rapid multiplication of parenchymatic tissues with reduction and distortion of the firm conductive tissues of the plant and the final decay and sloughing off of the spongy tissues, leaving open wounds, on the margins of which fresh developments of the tumor may appear.

Seed Corn as a Means of Disseminating Bacterium Stewarti: ERWIN F. SMITH.

In the summer of 1908, in a hothouse on the grounds of the Department of Agriculture, the writer succeeded in obtaining from plants grown from a suspicious seed corn eight times as many cases of Stewart's disease as from plants grown from disinfected seed taken from the same sack. The plants were treated in all respects exactly alike, except that a portion of the seed corn was planted without disinfection and other portions were subjected for ten minutes and fifteen minutes to 1:1,000 mercuric chloride water. The mere statement that there were eight times as many cases in the plants grown from untreated seed by no means expresses the whole truth, because in the plants grown from treated seed all the cases, with four exceptions, were very slight ones, every plant being reckoned as diseased which showed a

[1] In session December 29–31, 1908. These abstracts were received after the general report of the society had been printed in the issue of SCIENCE for June 25.