

ART. XLI.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum*; by J. L. WORTMAN.

[Continued from p. 176.]

CLASSIFICATION OF THE PRIMATES.

IN dividing this order into its primary branches, the first and most necessary step is to obtain, if possible, a clear and comprehensive understanding of the essential or fundamental features which characterize the several lines upon the basis of their evolution. It is naturally to be expected, that, as we approach the point of common origin, these features will become less and less accentuated, and those characters which in the final development have become most pronounced, will be found to be inconspicuous and apparently of little significance in the beginning.

It should be also remembered, that, while some of the phyla have progressed along the lines of their final development with comparative rapidity, and have modified many of the characters which were more or less common to all Primates in the earlier stages of their history, others have retained the primitive features to a greater or less extent. Thus, the presence of such characters as an increased number of premolars, the tritubercular condition of the molars, the small size of the cerebral lobes, with the greater or less development of their several parts, the presence of a floccular fossa of the skull, a third trochanter of the femur, or an entepicondylar foramen of the humerus, the possession of claws instead of nails on the terminal phalanges, as well as many other similar characters, are to be looked upon as common primitive features which characterize all early Primates. Any one of the phyla may have separately and independently modified these features according to the requirements of a new environment.

As an example in illustration of this statement, one might meet with a Primate in which the premolars were much reduced in number, in which the molars were fully quadritubercular, the face much shortened, the brain highly developed, the temporal and orbital fossæ separated by a bony plate; in short, in which might be found many of the characters of the most highly developed Primates; but if, at the same time, the specimen exhibited the peculiarities of the incisors, canines, and the caniniform lower premolar, as well as the cerebral circulation characteristic of the lemurs, one could be perfectly certain that the species was genetically related to and belonged in the Lemuroidea and was not a

member of the Anthropeidea.* We therefore finally come to learn what the essential or fundamental characters really are, and in proportion as our knowledge increases in this direction, in just that proportion shall we be able not only to arrange the species, genera, families, etc., in their true and proper relations to each other, but at the same time may feel assured that such an arrangement represents something more than a mere convenience.

As long as we hold fast to the old horizontal system, our classification will be artificial and unsatisfactory. This is nevertheless oftentimes necessitated by our lack of knowledge, but whenever evidence from the extinct forms is to be had, sufficient to furnish even an incomplete glimpse at the phyletic history, we shall always obtain much more satisfactory results by arranging our classification accordingly. It is by reason of this increase in our knowledge of extinct forms that frequent innovations are necessary, in order to give some expression to the general affiliations which the new discoveries reveal. Our knowledge of the more exact relationships of the various representatives of the Primates is still far from complete, yet I am persuaded that a considerable advance over the older conceptions is now not only possible but urgently demanded. The classification herein proposed introduces some novel features, which may or may not stand the test and be justified by future discovery, but it none the less denotes an effort to give expression to some of the genetic affinities of the several known types of the order, which a study of the extinct forms reveals.

It has been customary to include among the Primates the North American Hyopsodidæ, a small family containing two genera and some four or five species, which are limited in their vertical distribution to the Middle and Upper Eocene strata. Hitherto, nothing has been known of the skeleton, and consequently they have been placed in various positions within the order. In the skull, of which a fairly complete specimen was found by me in the Washakie Basin, Wyoming, in 1895, and is now preserved in the collections of the American Museum, there is no ossified tympanic bulla, and the carotid canal enters the cranium as in the Insectivora. The *foramen ovale* is placed well within the alisphenoid, and is not a notch

* Such an example was, in fact, an actual occurrence. Dr. Forsyth Major discovered an extinct Primate in Madagascar, which he named *Nesopithecus*. From the unusually high development of the skull, and its many resemblances to the higher apes, he concluded that it was an Anthropoid. Lydekker, however, justly criticised this view, and pointed out that, owing to the distinctly lemurine character of the incisors and the caniniform enlargement of the first lower premolar, it should be classed as a highly developed Lemuroid.

in its posterior border completed by the periotic, as is so frequently, if not universally, the case in the lemurs. The incisors are three above and below, and the lachrymal canal is located within the orbit. Although not positively known, it is probable that the lachrymal did not have an extraorbital extension. The pattern of the molars is unlike that of any known Primate, but in many respects is like that of certain primitive Ungulates. From several fragmentary skeletons in the Marsh collection, I am now fortunately able to state that the limbs were totally unlike those of the Primates. In the presence of a supertrochlear foramen, the humerus differs from that of any known Primate. The metapodials do not display the typical globular heads of those of the Primates, but are depressed and strongly keeled at their distal ends. The phalanges are short and stout, and give to the foot a distinctly terrestrial rather than an arboreal character; and, lastly, may be noted the very important character of a completely nonopposable hallux. The North American Hyopsodidæ do not, in fact, possess a single Primate feature, as far as can be discovered, but on the contrary are much more like the Insectivora, to which order I refer them. A summary of the foregoing characters, in which they differ from typical Primates, may be given as follows:

(1) There are three incisors above and below; (2) there is no ossified tympanic bulla; (3) the structure of the molars is not like that of the Primates; (4) the entocarotid circulation is like that of the Insectivora; (5) the limb bones differ from those of any known Primate; (6) the metapodials are not Primate; (7) the phalanges are short; and (8) the hallux is not opposable.

It would appear from the evidence obtained that there are no less than three distinct primary divisions of the order now known, and as these represent as many subordinal groups, the Primates have accordingly been divided into three sections.

The first group which is deserving of a subordinal rank among the Primates, although not commonly admitted, is that represented by the living Aye Aye of Madagascar. Along with this go the American Eocene genera *Mixodectes*, *Cynodontomys*, *Microsyops*, *Smilodectes*, and *Metacheiromys*. The most distinctive and important features of this group consist in the enlargement of the central pair of incisors, the limitation of the enamel to their anterior faces in the later forms, in consequence of which they wear into chisel-shaped points, and, finally, their growth from persistent pulps. Concomitantly, the outer incisors and canines disappear, and the mandibular condyles as well as the glenoid fossæ become modified and adapted to a longitudinal, instead of a vertical

movement of the lower jaw, as in the Rodentia. The ento-carotid circulation in *Cheiromys* is like that of the lemurs; the lachrymals are large, with extraorbital extension, and the external opening of the lachrymal canal is outside of the orbit. As in the lemurs, the lachrymal and malar are in contact. *Cheiromys* also agrees with the lemurs in having the fourth digit of the manus the longest of the series, and, except for the hallux, the terminal phalanges are clawlike. In all, there is a well-ossified tympanic bulla, and the limbs and feet are elongate and fully adapted to arboreal life.

Owing to the wide separation both in time and space, it has been doubted whether there is any genetic connection between the aberrant Madagascar species and the extinct North American forms. Indeed, Osborn has recently placed the American series in a primitive suborder of the Rodentia, which he calls the Proglires. After a careful investigation of the evidence, I do not hesitate to state it as my belief that the Madagascar and American forms are intimately related. There can be no two opinions respecting the Primate affinities of *Cheiromys*. This has long since been settled beyond all dispute, and although but comparatively little of the skeleton of the American species is known, what is known betrays the same Primate stamp with equal distinctness. In the New World forms, we have the following conditions presented: Ancient primitive Primates undergoing a rodent-like modification of the central pair of incisors, together with the disappearance of the outer pair and the canines. In American genera, the process is progressive but incomplete, while in the living Madagascar species the modification is complete. No stronger general argument, it seems to me, could be put forth in favor of their relationship, especially when it is remembered that these are the only representatives of the Primates in which the slightest tendency toward such modification is shown. That so distinctive and profound a change could have originated twice independently, in the same order, is so highly improbable as to be unworthy of serious consideration. That the group is of pre-Tertiary origin is shown by the fact that *Mixodectes*, its oldest representative, is already highly modified in the Torrejon or second stage of the Lower Eocene. I propose for the suborder the slightly modified term *Cheiromyoidea*.

The second suborder of the Primates includes the lemurs, a group which has long been recognized by zoologists as constituting a primary division of the order. Some authorities are inclined to deny the genetic connection of this group, as well as that of the *Cheiromyoidea*, with the true monkeys, and assign to them a separate and independent ordinal rank. This,

however, is manifestly incorrect, as all the evidence from both living and extinct forms tends to show.

Their chief characters derived from the skeleton are the following: Like the preceding group, the main entocarotid does not enter the tympanic chamber; the lower incisors and canines, when present, are much compressed laterally, elongate, and procumbent in position; the first lower premolar is commonly enlarged, and functions as a canine; there is a well-ossified tympanic bulla; the fourth digit of the manus is the longest of the series; the lachrymal is very generally enlarged, with extraorbital extension, and the external opening of the lachrymal canal is always upon the outside of the orbit;* the lachrymal and malar are nearly always in contact.

Just what value is to be attached to the placentation, in estimating affinities, is a question difficult to decide, but it is believed, and strongly argued by some, that the lowly organized structures and generalized condition by means of which the foetal envelopes develop a connection with the lining membrane of the uterine walls during gestation furnish a sufficient reason for removing the lemurs widely from the monkeys. In like manner, the rudimentary condition of the posterior cornu and hippocampus minor of the cerebrum, as well as the convolution of the transverse colon, have been looked upon as characters of great significance in classification. While it is probably true that these characters derived from the soft anatomy indicate a wide distinction between existing monkeys and lemurs, yet it is much to be doubted whether these distinctions would not assume very small proportions, or completely disappear, did we have an Eocene monkey with which to make the comparison.

Touching the question of the value of the manner of placentation as applied to the classification of the Mammalia, it is well to recall the words of Flower and Lydekker on this topic. In speaking of the "deciduate" and "non-deciduate" varieties of placenta, they say: † "It was once thought that the distinction between those two forms of placentation is so important as to constitute a sufficiently valid basis for a primary division of the placental mammals into two groups. It has, however, been shown that the distinction is one rather of degree than of kind, as intermediate conditions may exist, and it is probable that in different primary groups the simpler, non-deciduate form may have become developed independently into one or other of the more complex kinds. * * * * We may conclude

* An exception to this last statement is found in the extinct Malagassy lemur *Nesopithecus* of Forsyth Major. In this species, according to its describer, both the lachrymal and the lachrymal opening are within the orbit.

† Mammals, Living and Extinct, 1891, p. 80.

that, although the characters and arrangement of the foetal structures may not have that extreme importance which has been attributed to them by some zoologists, they will form, especially when more completely understood, valuable aids in the study of the natural affinities and evolution of the Mammalia.”

In view of the important fact that the soft anatomy of extinct forms is wholly inaccessible and will remain forever hidden from us, and furthermore, not knowing exactly what value to attach to characters derived from this source among living forms, it seems by far the safest plan to rely largely, if not solely, upon osteological evidence for our conclusions respecting the affinities and evolution of the various groups of the Mammalia. The facts afforded by the skeleton are the only ones whereby we are permitted to make a direct comparison between the structure of living and extinct forms, and should, therefore, always be ranked as of the first importance.

The following are the chief primitive characters of the lemuroid skeleton: The cranial cavity is proportionately small; the face is generally large and elongate in comparison with the size of the brain case; the temporal and orbital fossæ are not separated by a bony plate (except in *Nesopithecus*); the zygomata are usually broad and heavy, and the malar frequently extends beneath the zygomatic process of the squamosal to near the glenoid fossa, as in the Marsupials; the malar articulates with the lachrymal in front in many species, thereby shutting out the maxillary from a share in the anterior or lower rim of the orbit; there is usually a considerable interorbital breadth; the squamosal has little vertical expansion on the side wall of the skull; there are nearly always large postglenoid foramina; the posterior free edge of the hard palate is thickened; the molars are for the most part tritubercular; the atlas has separate openings for the two divisions of the suboccipital nerve; the ilium is generally little expanded; the head of the femur is more or less sessile upon the shaft; the digital fossa has a slitlike form; the second trochanter is large and internal in position, and there is always a third trochanter; the proximal plantar extremity of the metatarsal of the hallux, for the attachment of the long peroneal tendon, is enlarged and prolonged; the second digit of the pes bears a terminal claw, and the humerus has an entepicondylar foramen.

It is at present difficult to decide just how many families should be recognized in this suborder. A conservative estimate would not place them above two or perhaps three. Of these, the living species would constitute one, the Lemuridæ; the extinct Malagassy *Nesopithecus* a second, the Nesopithecidæ, and very doubtfully the extinct *Megaladapis* a third, the

Megaladapidaë. It should be remembered, however, that the Lemuridaë, as thus constituted, include forms of very diverse structure and probably not very closely related. Thus the Indrisinaë, usually considered as one of the best-marked and most distinct subfamilies, in the absence of one pair of incisors or canines in the lower jaw, together with the strongly developed mesostyle of the superior molars, appear to be sufficiently differentiated from the central forms of the typical lemurs to be entitled to a distinct family rank.

The third and last primary division of the order is the Anthroipoidea, and in the present state of our knowledge it seems quite impossible to obtain any very clear insight into the phyletic history of the various groups composing it. Until much additional information is secured concerning many of the fossil types already known, as well as of the large number of undiscovered connecting forms which must have certainly existed, any attempts at a classification that may be regarded as final can not at present be made. Still, certain advance steps may, I think, now be taken, which will help considerably toward a final solution of some of the many difficult problems involved in unraveling the tangled web of simian evolution.

The characters by means of which the members of the group are distinguished from the two foregoing suborders are as follows: Incisors reduced to two pairs above and below (in *Tarsius*, one below); they have a normal form and position; there is no caniniform enlargement of the first lower premolar; the entocarotids traverse the petro-tympanic; the lachrymal canal (except in one group) is more or less confined within the orbit, and the facial part of the bone is quite generally reduced; the lachrymal and malar are not in contact, leaving the maxillary a share in forming the anterior rim of the orbit; the fourth digit of the manus is never the longest of the series.

It would appear from present evidence that the Anthroipoidea early divided into at least three main branches, but the exact lines of descent from these starting points can not now be traced with any degree of certainty, among the majority of the living species. The first of these divisions is represented by the living marmosets, a group which Huxley classified under the name of the Arctopithecini.* Their chief claim to distinction consists in the lack of opposability of the hallux and pollex; the clawed condition of all the terminal phalanges of both manus and pes, except a slight flattening of that of the hallux; the loss of the third molar above and below, and the tritubercular condition of the superior molars. These characters, except the last, are unique among the Primates, and may or may not indicate a very ancient branching from the main

* Anatomy of Vertebrated Animals, 1872, p. 392.

axis. Whatever classification is finally adopted, it seems to me that this should be regarded as one of the primary divisions of the suborder, since the characters of the extremities are not found in any other member of the order thus far known.

In the second division of the Anthropeidea, I included *Tarsius* and its allies. It has been customary with nearly all authorities to classify this species in the Lemuroidea, assigning to it the rank of a separate and distinct family. Hubrecht,* however, from a careful study of its placentation has shown that in this respect it is widely different from the lemurs and decidedly like the monkeys. Hence, he has proposed its removal to the Anthropeidea. In confirmation of this view, it may be added that the entocarotid circulation, which I am inclined to regard as of fundamental importance, is analogous to that of the primitive monkeys and not like that of any of the lemurs. Similarly, the lack of union between the malar and lachrymal is found in all the monkeys, and the reverse condition in the lemurs. The teeth do not exhibit that peculiar modification seen in all lemurs, but again are like those of the monkeys; and, lastly, the fourth digit of the manus is not the longest of the series as in all the lemurs, but is shorter than the third as in the monkeys. Thus, it will be seen that the evidence derived from five independent sets of organs, the placentation, lachrymo-malar union, entocarotid circulation, dentition, and digital lengths of the manus, all concur in assigning to *Tarsius* a position with the monkeys and not with the lemurs. On the other hand, it may be stated that in the extraorbital extension of the lachrymal and the location of the external openings of the lachrymal canal outside the rim of the orbit, it agrees with the lemurs.

This question of the lachrymal region in the skull of the Primates has recently formed the subject of extensive and painstaking research by Forsyth Major.† From his investigations, we learn that, with the single exception of *Nesopithecus*, a highly developed extinct type from Madagascar, all the lemurs possess an enlarged lachrymal which reaches beyond the orbit, while the external opening of the lachrymal canal is situated upon the side of the face. In some species, notably *Loris*, no lachrymal was found, but there can be little doubt that its absence is due to early fusion with the maxillary and complete obliteration of the sutures, as in the sea-lions and seals. Another interesting observation recorded by Dr. Major relates to the lachrymal enlargement seen in certain South

* Die Keimblase von *Tarsius*. Festschrift für Carl Gegenbaur, Leipzig, 1896. The Descent of the Primates, Princeton Lecture, 1897.

† On Some Characters of the Skull in Lemurs and Monkeys, Proc. Zool. Soc. London, February, 1901.

American apes, as the howlers and woolly spiders, wherein it is impossible to decide whether the lachrymal canal can be said to be within or without the orbit. In view of these transitional conditions, the great taxonomic significance of the position of the lachrymal canal, which it was formerly thought to possess, is materially weakened. The large lachrymal with the opening of the canal extraorbital in position is undoubtedly the primitive condition. This is demonstrated by reference to the Marsupials, in some of which, notably *Myrmecobius*, it is unusually large and sends a considerable spur outward upon the zygoma to join the malar. In all Insectivora, Rodentia, and primitive Carnivora, the enlarged lachrymal as well as the extraorbital position of the canal, is, as far as I am aware, universal.

For views in favor of retaining *Tarsius* in the Lemuroidea, as well as for a general discussion of the genetic relationship of the latter to the Anthroipoidea, I refer the reader to the excellent papers by Mr. Charles Earle.*

If *Tarsius* is a member of the suborder Anthroipoidea, of which in my judgment there can be little question, then it appears equally certain that, with its allies, it represents an independent branch from the main axis, and one, moreover, of equal rank with the Arctopithecini, or marmosets, since its primitive lachrymal arrangement associated with precocious tooth reduction, as well as with some peculiarities of the pterygoid region, mark it off distinctly as a side branch. I suggest for this group, therefore, the name Paleopithecini.

Of the extinct American types, *Euryacodon* and *Anaptomorphus* are names which probably refer to one and the same genus. The skull structure of the best-known species, *Anaptomorphus* or *Euryacodon homunculus*, was described by Cope from an exceptionally fine specimen found by me in the Wasatch bed of the Big Horn Valley, Wyoming, in 1881. This specimen has recently been refigured by Osborn.† Its resemblance to *Tarsius* is so striking that there can be apparently no question whatever of the near relationship of the two. This is seen in the following important characters: The entocarotid canal traverses the tympanic chamber, and its external orifice is situated as in *Tarsius*; the malar does not unite with the lachrymal; the lachrymal is relatively large and extends out upon the face; the external opening of the lachrymal canal is extraorbital in position; the auditory bullæ are much inflated and the external alæ of the pterygoids extend outward and backward in such a manner as more or less to enclose the bullæ; the structure of the teeth

* Science, February 12, 1897; and May, 1897. American Naturalist, July and August, 1897.

† American Eocene Primates, Bull. Amer. Mus. Nat. Hist., June, 1902.

resembles that of *Tarsius* very closely, and the premolars in the Bridger species at least are reduced to two; there is no lemurine modification of the incisors or first lower premolar; the brain is relatively large, and the face is considerably bent down on the basicranial axis, as in *Tarsius*; while, lastly, the species are small and the orbital cavities enlarged.

From this striking array of similarities which Cope was careful to point out, I am fully convinced that the two forms are closely related and should be placed in the same group. In like manner, we may feel reasonably certain in arranging the extinct European *Necrolemur* of Filhol in the same group. Although the skull characters are less perfectly known than in the American species, yet the lachrymal region, the dentition, and the general appearance of the single skull known, all betray the same fundamental resemblances to *Tarsius* noted in *Anaptomorphus* or *Euryacodon*. I do not hesitate, therefore, to classify it with this series. The same may also be true of the imperfectly known *Microchærus* of the European Eocene, but this is not at all certain. There is some evidence that the latter genus is closely related to and represents *Hyopsodus* in Europe.

The position of the remaining American genera, *Omomyys*, *Hemiacodon*, and *Washakius*, is more problematical. No complete skull of any of these forms is known, and it is impossible to say whether they most resemble *Tarsius* or the monkeys. In one species, *Hemiacodon gracilis*, a fragment of the maxillary is sufficiently preserved to show that there was no union between the malar and lachrymal. The incisors do not display any lemurine characteristic and the inference is tolerably clear that they belong either with the Paleopithecini or with the true monkeys. I may add just here that there is such a marked resemblance between the teeth of *Omomyys* and those of certain of the living South American Cebidæ, that I am strongly inclined to the belief that these extinct forms are true monkeys.

There yet remains to be discussed another group of extinct Primates whose remains are better preserved, and hence more completely known, than any others yet discovered in the Eocene, the Adapidæ of Europe and the so-called Nothartidæ of America. Cope* arranged them in the group Mesodonta, which he made a suborder of his order Bunotheria. He included in the Bunotheria the suborders Creodonta, Mesodonta, Insectivora, Tillodontia, and Tæniodonta, at the same time holding that the Prosimiæ, or Lemuroidea, should be placed here as well. He seems to have entertained the opinion that all were ordinarily distinct from the Quadrumana, or Primates, although

* Tertiary Vertebrata, 1884.

he does not state this directly. He defined the Mesodonta as follows: "Incisors not growing from persistent pulps; molars tubercular, never sectorial; third trochanter elevated; astragalus not grooved above." Under the head of Prosimiæ, he further adds, "The suborder may be differentiated from the Mesodonta by the possession of an opposable hallux of the posterior foot," but qualifies this definition with the statement that the lack of opposability of the hallux is not demonstrated in any of the species except *Pelycodus*.

There seems to be a great deal of confusion in Cope's statements regarding the classification of the genera under the Mesodonta and Prosimiæ. In the Mesodonta, he classified the following genera: *Omomys*, *Microsyops*, *Pantolestes*, *Tomitherium*, *Pelycodus*, *Sarcolemur*, *Hyopsodus*, *Aphelicus*, *Adapis*, and *Opisthotomus*. In the Prosimiæ, on the other hand, he included three families, viz.; Adapidae (genera not stated), Mixodectidae comprising the genera *Mixodectes*, *Microsyops*, and *Cynodontomys*, and the Anaptomorphidae including *Anaptomorphus* and *Necrolemur*. It will be thus seen that several of the genera are referred to both suborders.

The next authority of note to contribute to this subject is Schlosser. He regarded all these early extinct forms as constituting a group equal in rank to that of the Lemuroidea and Anthropeidea, and one from which these two, in all probability, have been derived. This group he named the Pseudolemuroidea. Osborn in his recent paper, "American Eocene Primates,"* inclines apparently to the same view. He says: "Three suppositions are possible: First, that these Primates represent an ancient and generalized group (Mesodonta, Cope) ancestral to both Lemuroidea and Anthropeidea; second, that they include representatives of both Lemuroidea and Anthropeidea, contemporaneous and intermingled; third, that they belong exclusively to one or the other order. There are certain advantages in the revival of the term Mesodonta Cope, a suborder (anticipating the terms Pseudolemuroidea and Tarsii) which would bear somewhat the same relationship to the modern specialized Monkeys and Lemurs that the Condylarthra bear to the Ungulata and the Creodonta to the Carnivora."

As regards the validity of the group Mesodonta of Cope and its suggested revival by Osborn, very little need be said. From the most abundant skeletal materials of both *Adapis* and *Notharctus* we now know that the hallux was almost if not quite as opposable as in any living Primate. Cope's statement, therefore, of its lack of opposability in *Pelycodus*, a genus scarcely distinct from *Notharctus*, must with almost absolute

* Loc. cit.

certainly be erroneous. His technical definition of the group, moreover, as well as its dissociation from the Primates, I regard as utterly unsound, illogical, and in no wise warranted by the facts. I do not believe that any such natural group exists, and a revival of the name Mesodonta can result only in confusion. As we have already seen, there are types of very different affinities among these ancient Primates, and this fact in my judgment effectually precludes the possibility of their association into a single group. What position, then, do *Adapis* and *Notharctus* occupy with reference to these natural groups already outlined? That they can not be consistently placed in the Lemuroidea is evident for the following reasons: The incisors do not exhibit any traces of lemurine modification, but, on the contrary, are like those in typical monkeys; the main entocarotid canal traverses the petro-tympanic chamber as in *Tarsius*; the lachrymal and malar do not unite on the anterior rim of the orbit; the digital lengths of the manus are not known with certainty, but in *Notharctus*, the evidence is reasonably conclusive that the fourth was not longer than the third.

On the other hand, their resemblance to the Paleopithecini is more marked. This is seen in the greatly inflated condition of the tympanic bullæ as well as in the outward and backward extension of the external alæ of the pterygoids. These forms differ from the Paleopithecini, however, in having a more reduced lachrymal, in the position of the external opening of the lachrymal canal on or near the rim of the orbit, in having a greater number of premolars, and in general in being larger and of more robust proportions. Thus, it will be seen that they occupy a position intermediate in many respects between the remaining Anthropoidea and the Paleopithecini. In the latter, there seems to have been a marked tendency toward precocious specialization in both tooth reduction and brain enlargement, which are curiously associated with retention of the primitive condition of the lachrymal. *Adapis* and *Notharctus*, on the other hand, exhibit advance in the reduction of the lachrymals, but retain the more generalized features of the dentition and brain enlargement. These are the essential differences between the two lines and mark out very distinctly the trend as well as the possibilities of their future development. It is in just such a group as that which includes *Adapis*, *Notharctus*, and *Limnotherium*, that we must seek for the beginnings of the higher monkeys and apes which follow; and while these species, at present the only well-known types of the series, may not have been in the direct line of descent, they can not at the same time have been far removed from it. *Omomy*s and *Washakius*,

as far at least as we are permitted to judge from their scant remains, are closely related to *Adapis* and *Notharctus*, but had made greater progress in the reduction of the premolars. This gives an especially monkey-like appearance, pointing particularly in the direction of certain living Cebidæ. It is probable, therefore, that all this series should be classified as primitive members of a third section of the Anthropoidea. If this last division represents a homogeneous and natural group, equivalent in rank to that of the Arctopithecini and Paleopithecini, it is deserving of a name, and I suggest for it that of Neopithecini.

A summary of the foregoing discussion of the classification of the Primates, together with the more technical definitions of the several groups, is embodied in the following statement:

Limbs elongate, with prehensile manus, and pes fully adapted to an arboreal life; incisors enlarged and in later forms becoming reduced in number and rodent-like in pattern; canines disappearing in later forms; an ossified tympanic bulla; entocarotid circulation as in the Galaginæ and Lorisinæ; three families, Microsypsidæ, Metacheiromyidæ, and Cheiromyidæ.

Cheiromyoidea.

Limbs elongate, prehensile, and adapted to an arboreal habit; incisors of lower jaw reduced in size, pectinate, and proclivous in position; anterior lower premolar very generally enlarged and functioning as a canine; entocarotid canal not traversing the petro-tympanic; malar and lachrymal very generally in contact on anterior rim of orbit; fourth digit of the manus the longest of the series; three families, Lemuridæ, Indrisidæ, and Nesopithecidæ.

Lemuroidea.

Limbs elongate, extremities prehensile, and fully adapted to an arboreal life; incisors and canines normal in form and position; entocarotid traversing petro-tympanic; malar and lachrymal not in contact on anterior rim of orbit; fourth digit of manus shorter than third; three superfamilies or groups, Arctopithecini, Paleopithecini, and Neopithecini.

Anthropoidea.

The definitions and divisions of the superfamilies of the Anthropoidea are as follows:

Hallux and pollex of manus and pes not opposable; true molars reduced to two in each jaw; one family, Hapalidæ.

Arctopithecini.

Hallux and pollex fully opposable; three true molars; lachrymal enlarged, with well-developed *pars facialis*; lachrymal canal opening without orbit; premolars precociously reduced in highest forms; two families, Anaptomorphidæ and Tarsiidæ.

Paleopithecini.

Hallux and pollex fully opposable; three true molars; lachrymal reduced; lachrymal canal opening on or inside orbital rim; premolars progressively reduced to two in advanced forms; brain enlargement progressively increasing in the later types; five families. Neopithecini.

The Neopithecini are divisible into at least five distinct families of which in the living fauna three are confined to the Old World* and one to the New World. One extinct family is common to the two hemispheres, and as far as can be now ascertained from the remains, occupies a position not far removed from the common primitive stem from which the great majority of the living simian population of the Old and New Worlds originated. In the case of the Old World families, the gap is as yet very wide, but in the case of the New World Cebidæ, the interval is much less, and is not greater than one would be reasonably led to anticipate between an ancestor of Upper Eocene time and a living descendant. In fact, the difference is not nearly as great as it is between the modern horse and its Upper Eocene progenitor, *Orohippus*. As this phase of the subject will be more fully discussed in another section of the present paper, it may be here dismissed.

The families of the Neopithecini are distinguished upon osteological considerations, as follows:

Premolars four above and below; orbital and temporal fossæ more or less freely continuous; parietal uniting with alisphenoid on side wall of cranium; molars more or less fully quadritubercular, with ridges of superior trigon distinct; a large petro-tympanic bulla expanded behind; external auditory meatus not prolonged into a tube; carotid canal piercing bulla near postero-external angle; a postglenoid foramen; muzzle elongate; lachrymal slightly extended beyond rim of orbit, with opening of lachrymal canal upon edge of orbit; ilium little expanded; ischium without distal enlargement or everted edges; head of femur more or less sessile upon shaft; digital fossa of femur narrow and slitlike; a third trochanter and an entepicondylar foramen; hallux fully opposable; metatarsal of hallux with elongate proximal plantar extremity; pollex not as fully opposable as in higher species; foramina of atlas complex. Adapidæ.

Premolars three above and below; orbital and temporal fossæ separated by bony plate; parietal uniting with alisphenoid on side wall of cranium; frontal excluded from contact with alisphenoid by malar on side of skull (except in *Mycetes* and some species of *Ateles*); molars fully quadritubercular, with ridges of superior trigon distinct; first lower premolar without elongate

* In this statement, the origin of man is considered to have taken place in the Old World.

anterior border, as in preceding family; petro-tympanic bulla little expanded behind; no vaginal process; auditory meatus not prolonged into a tube; carotid canal piercing bulla near postero-internal angle; a large floccular fossa on internal surface of periotic; postglenoid foramen present or absent; muzzle abbreviated; lachrymal either slightly extended beyond rim of orbit or confined wholly within it; ilium well expanded; ischium without distal enlargement and edges not everted; head of femur with well-defined neck and an open digital fossa; no third trochanter; an entepicondylar foramen of humerus; hallux fully opposable; metatarsal of hallux without elongate proximal plantar extremity; pollex not as fully opposable as in higher species; foramina of atlas complex. Cebidæ.

Premolars two above and below; orbital and temporal fossæ separated by bony plate; no parieto-sphenoid but a temporo-frontal contact in the side wall of the cranium; frontal and alisphenoid not separated by malar on side wall of cranium; molars fully quadritubercular of squarish outline, without traces of superior trigonal ridges, but tending to the formation of cross crests; first (third) inferior premolar with characteristic elongation of anterior border; petro-tympanic bulla little inflated and filled with cancellous tissue; no vaginal process; auditory meatus prolonged into a bony tube; carotid canal piercing bulla near postero-internal angle; a large floccular fossa on inner surface of periotic; presphenoid and basisphenoid remaining long distinct, as in preceding family; no postglenoid foramen; muzzle abbreviated; lachrymal never reaching rim of orbit, and of much greater vertical than-transverse extent; ilium well expanded; ischium with distal enlargement and everted edges; head of femur with well-defined neck and an open digital fossa; no third trochanter; no entepicondylar foramen of humerus; hallux fully opposable; metatarsal of hallux without elongate proximal plantar extremity; pollex fully opposable; foramina of atlas complex or simple. Cercopithecidæ.

Premolars two above and below; canines enlarged and of greater vertical extent than premolars and incisors, as in preceding families; orbital and temporal fossæ distinct; a temporo-frontal contact on side wall of skull (except in Orang); frontal and alisphenoid not separated by malar on side wall of cranium; molars fully quadritubercular, with more or less rounded outline, without any tendency to the formation of transverse crests, but with distinct remains of superior trigonal ridges; first (third) inferior premolar with traces of elongate anterior border (least distinct in Chimpanzee); petro-tympanic bulla little inflated, with a moderately well-developed vaginal process (except in *Hylobates*) and no ossified styloid process as in preceding families; auditory meatus elongate; carotid canal as in Cercopithecidæ; floccular fossa on internal surface of periotic vestigial;

no postglenoid foramen; presphenoid and basisphenoid early coössified; lachrymal confined within the orbit, having a quadrate outline without vertical enlargement (except in *Hylobates*); ilium expanded; ischium with only moderate distal enlargement and without strongly everted edges (except in *Hylobates*); head of femur with well-developed neck and open digital fossa; no third trochanter; no entepicondylar foramen; hallux and metacarpal of hallux as in Cercopithecidæ; pollex fully opposable; sesamoids of flexor tendons of four outer digits in manus and pes vestigial or wanting and keels absent (except in *Hylobates*); foramina of atlas simple; as in the preceding families, the mastoid process is rudimental or wanting and the premaxillo-maxillary suture long persists, being obliterated only in aged specimens; there is no foramen spinosum for the passage of the middle meningeal artery, but a notch in the anterior external part of the foramen ovale apparently represents it in the Gorilla and Chimpanzee; the frontals meet in the middle line over the presphenoid and behind the ethmoid (except in Orang. Simiidæ.

Premolars two above and below; canines reduced and of no greater vertical extent than premolars and incisors; orbital and temporal fossæ distinct; a sphenoparietal contact on the side wall of cranium (variable); frontal and sphenoid not separated by malar on side wall of skull; molars fully quadritubercular with superior trigonal ridges distinct; first (third) inferior premolar without any trace of elongate anterior border; no petrotympanic bulla; but a well-defined vaginal process and a well-ossified and coössified stylohyal; external auditory meatus and carotid canal as in Simiidæ; no postglenoid foramen; no floccular fossa on inner surface of periotic; presphenoid and basisphenoid early coössified; lachrymal confined within the orbit, having a much greater vertical than antero-posterior diameter; distal enlargement of ischium reduced and edges not everted; neck of femur and digital fossa as in Simiidæ; hallux enlarged, not opposable and in line with other digits; keels, grooves, and sesamoids of four outer metapodials of manus and pes absent; foramina of the atlas simple; a well-developed mastoid process; the maxillo-premaxillary suture early obliterated; a distinct foramen spinosum for the passage of the middle meningeal artery; no union of frontals over presphenoid and behind ethmoid. Hominidæ.

[To be continued.]