56.9,88H:14.31,4

Article XIII.—FURTHER NOTES ON THE MOLARS OF *HESPEROPITHECUS* AND OF *PITHECANTHROPUS*

By William K. Gregory and Milo Hellman

With an Appendix Entitled

NOTES ON THE CASTS OF THE *PITHECANTHROPUS* MOLARS

By Gerrit S. Miller, Jr.

In response to our request, Dr. Gerrit S. Miller, Jr., of the U. S. National Museum, has kindly examined our manuscript and submitted a number of important suggestions and criticisms. The National Museum has also very generously loaned us for comparison a large series of upper molars of orangs, chimpanzees, and gorillas. Dr. Miller's notes and material raise again the following questions:

1.—Is the type of *Hesperopithecus* a third upper molar, as Dr. Miller is inclined to think, or is it a second upper molar as suggested in our previous paper?[1]

2.—With regard to arrangement and form of the roots, is the *Hesperopithecus* type more like the orang, the chimpanzee, the gorilla, or man?

3.—Of the characters revealed in the *Hesperopithecus* type can we separate those which indicate its position as a member of the man-anthropoid series from those which distinguish it from the different genera of this group?

4.—What is the homology of the paratype tooth of *Hesperopithecus?* Is it an upper or a lower molar and which molar is it?

5.—Besides these questions the problem is again raised as to the nearer resemblances and differences of the second and third molars commonly attributed to *Pithecanthropus.*

6.—Finally, is it possible that the *Hesperopithecus* molar might represent not a primate but a carnivore, as Dr. Smith Woodward is still inclined to think?

1.—IS THE TYPE OF *HESPEROPITHECUS* A SECOND OR A THIRD UPPER MOLAR?

We have been inclined to regard it as a second upper molar for the following reasons.

[1]Gregory, William K., and Hellman, Milo. 1923. 'Notes on the Type of *Hesperopithecus haroldcookii* Osborn.' American Museum Novitates, No. 53.

(*a.*) Its extreme wear, which is unusual in third upper molars of known men and apes.

(*b.*) As noted in our first paper, it approaches the second upper molar of a certain chimpanzee in the transverse diameter of the posterior moiety of the crown, in the angle of the outer surface of the crown to the anterior surface, and in the degree of divergence of the axis of the lingual root to that of the anterior buccal root.

We have, however, recently noticed the cast of a very old gorilla (A. M. N. H. No. 198) in which the third upper molar is almost as much worn down as that of the type of *Hesperopithecus*. One of the gorilla third molars of the National Museum collection (No. 176212) has a contour of the crown which is less unlike the *Hesperopithecus* type than any other gorilla examined (Fig. 3). It widely differs, however, in the inclination of the occlusal surface to the axis of the palatal root (Fig. 3). In *Hesperopithecus*, if the general occlusal plane is placed in a horizontal position, the palatal root is inclined slightly forward. In this gorilla the homologous axis is inclined strongly backward, and this seems to be true of many third upper molars of various anthropoids and men. It must be admitted that the general form of the crown of one specimen and the appearance of the root of another gorilla m^3 approach *Hesperopithecus* and afford support to Dr. Miller's view. But, in our judgment, the wide difference in inclination of the occlusal surface to the vertical axis of the root constitutes an objection to the type of *Hesperopithecus* being a third upper molar. In these relations its most significant resemblances appear to be with the second or first upper molar of certain men (Fig. 3).

In answer to the preceding paragraph Dr. Miller replies (December 7, 1922) as follows:

> I think you give undue weight and a wrong interpretation to the slant of the inner root with relation to the plane of the occlusal surface. In the third molar of gorillas I find that this slant appears always to begin by being backward, but as wear of the crown goes on it tends to work over to a forward condition which in a tooth as much worn as No. 176206 may become so like the slant in *Hesperopithecus* that I think you are wholly unjustified in placing such reliance on this feature of the fossil as your remarks on page 9 would indicate. With the third molar of No. 176206 I am sending the second [molar] tooth. Here you will see the slant of the inner root is backward instead of forward.

Our Fig. 3 shows that with regard to the point under consideration the *Hesperopithecus* type agrees with first and second upper human molars more than with the third upper gorilla molars. To this statement Dr. Miller, in turn, replies (March 14, 1923): "But the differences in this respect between one gorilla tooth and the human teeth is very much less than that between the two gorilla teeth."

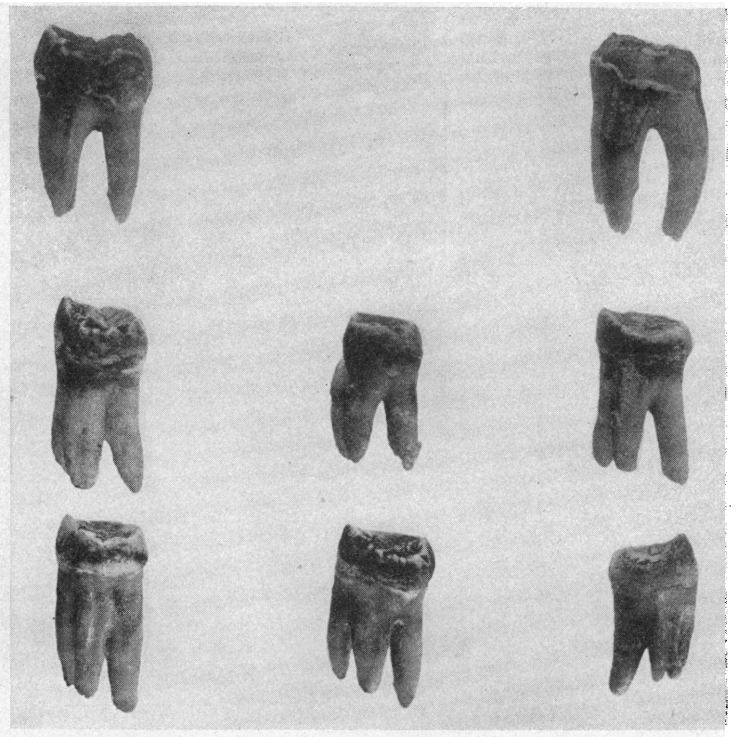

Fig. 1. Series of orang third upper molars showing wide variability in size. U. S. Nat. Mus. specimens. Natural size. All but the lower right hand specimen (which is an m^3 left) are third right upper molars, seen from the rear.

Upper row: U. S. Nat. Mus. Nos. 142181, 145313.
Middle row: U. S. Nat. Mus. Nos. 153807, 145300, 153820.
Lower row: U. S. Nat. Mus. Nos. 49853, 153805, 153813.

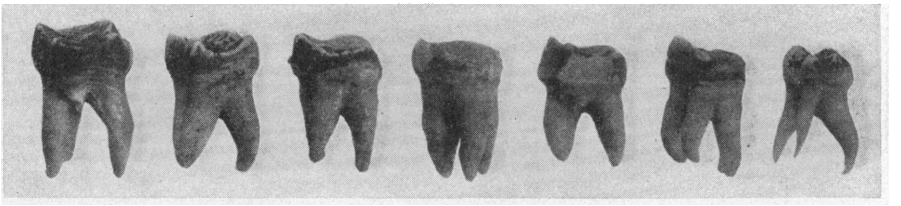

Fig. 2. Series of chimpanzee third right upper molars showing wide variability in size. Natural size.

A. M. N. H. 51394; U. S. Nat. Mus. Nos. 236977, 176235, 176240, 176241, 174710, 236971.

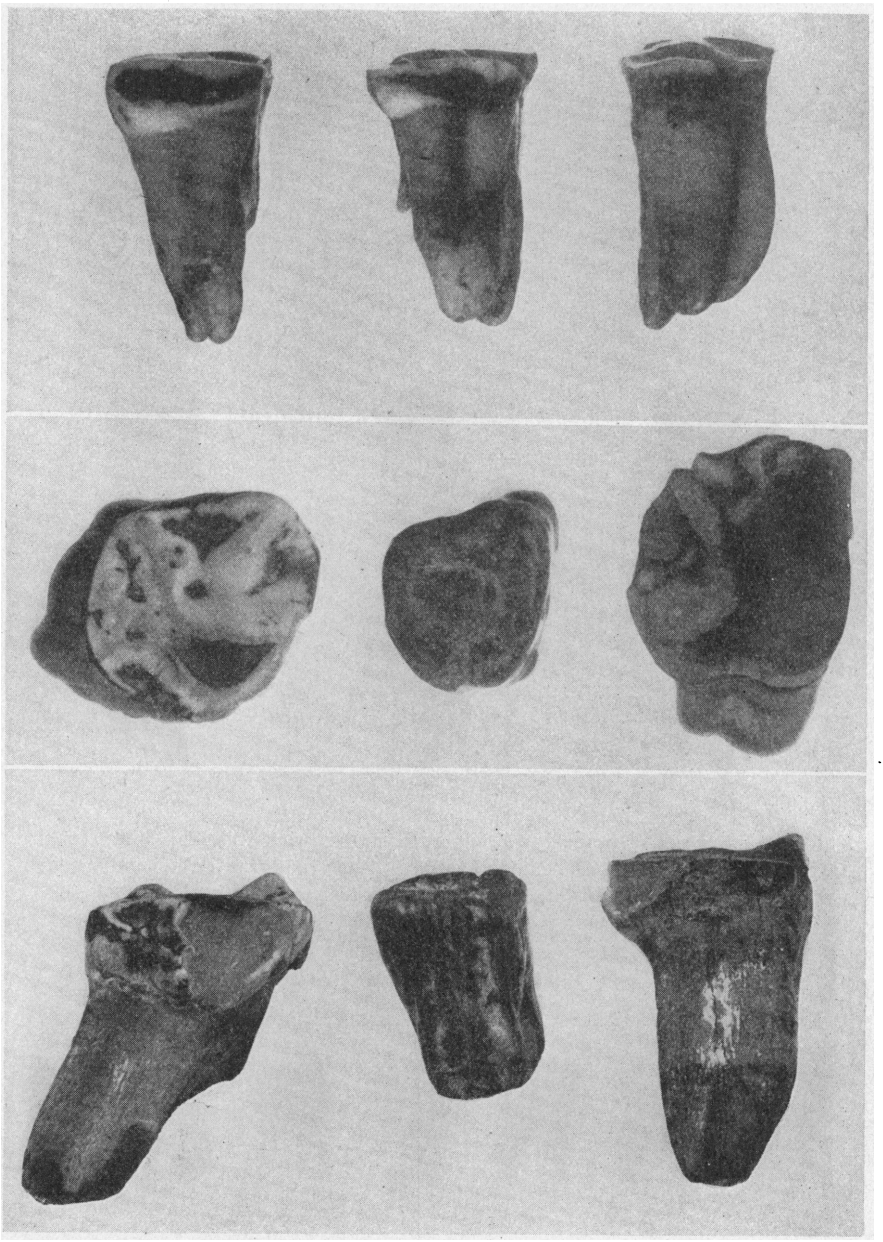

Fig. 3. Comparison of *Gorilla*, *Hesperopithecus* and human molars. × 2.

Upper row: Amerind m^2 (A. M. N. H. T 2162); m^1 of same; Amerind m^2 (A. M. N. H. T 2166). Lingual view.

Middle row: *Gorilla* sp. m^3 (U. S. Nat. Mus. 176212); *Hesperopithecus* type; *Gorilla* sp. m^3 (U. S. Nat. Mus. 176206). Crown view.

Lower row: *Gorilla* sp. m^3 (U. S. Nat. Mus. 176212); *Hesperopithecus* type; *Gorilla* sp. m^3 (U. S. Nat. Mus. 176206). Lingual view.

2.—WITH REGARD TO THE ARRANGEMENT AND FORM OF THE ROOTS, IS THE *HESPEROPITHECUS* TYPE MORE LIKE THE ORANG, THE CHIMPANZEE, THE GORILLA, OR MAN?

The orang third upper molars of the National Museum series differ immensely among themselves (Fig. 1) from a very large tooth 15.7 mm. in antero-posterior length to a very small tooth only 9 mm. in length. The former differs from the *Hesperopithecus* type in having a very large hypocone and two widely separated buccal roots; the latter differs from the same in having an excessively contracted crown with greatly crowded external roots. Several of the orang molars have long straight palatal roots of subcylindrical appearance. The postero-external root in orangs tends to be double and either to diverge from or not to converge toward the palatal root.

The National Museum material (Fig. 2) indicates that in chimpanzees the palatal roots of all the third molars are usually comparatively short, pointed toward the root end, and relatively weak, while those of the gorillas are long, stout, and not sharply tapering. In this point the *Hesperopithecus* type is decidedly nearer to the gorilla.

Next, the palatal root of the *Hesperopithecus* type is deeply grooved vertically on its buccal aspect. Dr. Miller suggests that there is a resemblance here (Fig. 4) with certain gorilla third upper molars (U. S. Nat. Mus. Nos. 174713 and 176205) in which the raised posterior border of the groove is formed through the coalescence of the postero-external (distobuccal) root with the palatal root. It is hardly possible that in *Hesperopithecus* the posterior border of the deep groove in question can be formed through a similar coalescence, because the radiographs (published in our previous paper, Fig. 5) show but one canal on the palatal side, while if any part of the postero-external root were present it should show another canal, or portions of it; secondly, a coalescence of this kind assumed by Dr. Miller would not account for the similar upraised border on the antero-internal side of the palatal root, where there is no question of any coalescence. While the grooved internal border is more pronounced than in any anthropoid or human specimen examined by us, this does not necessarily mean that there was a coalescence of the postero-external root with it. In fact, we are still inclined to think that the antero-external root was free at its apex but confluent at the base with the raised border of the palatal root and that a remnant of the forking between the antero-external and the palatal root is still visible.

In reply to the foregoing Dr. Miller writes as follows:

I should not expect to find a second canal present in a tooth formed and broken in the way I suppose the type tooth to have been formed and broken. My idea will

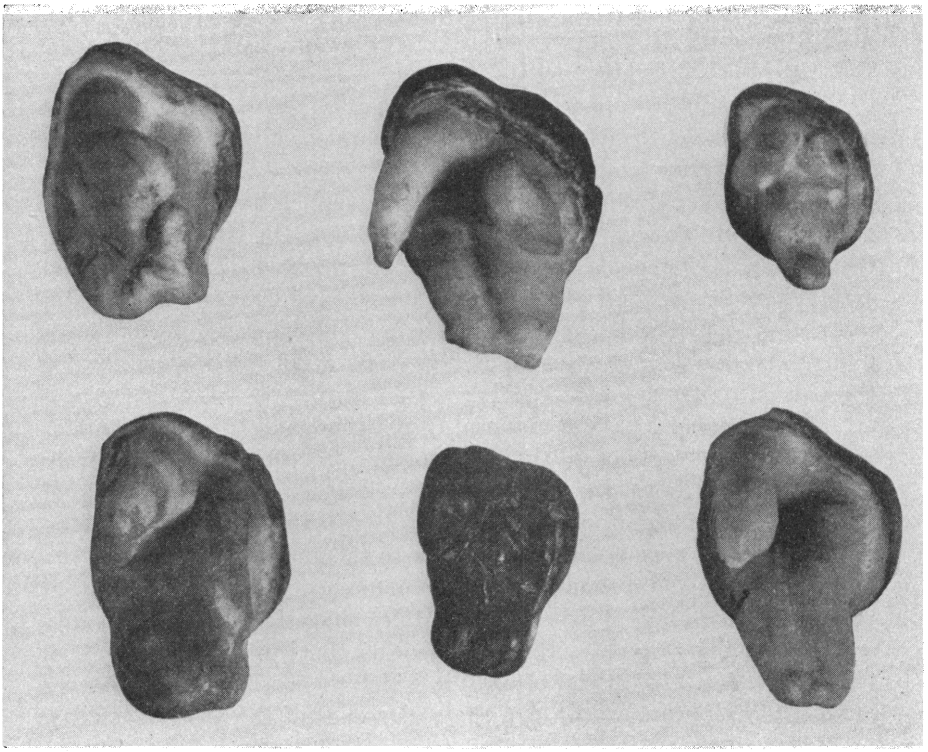

Fig. 4. Comparison of *Gorilla*, *Hesperopithecus*, orang and chimpanzee molars. Vi from above showing roots. × 2.

Upper row: *Gorilla*, U.S .Nat. Mus. No. 176212; orang, U. S. Nat. Mus. No. 142181; chimpanzee, A. M. N. No. 51394.

Lower row: *Gorilla*, U. S. Nat. Mus. 176206; *Hesperopithecus* type; *Gorilla*, U. S. Nat. Mus. 174716.

perhaps be made plain by the red ink on the roots of m^3 in gorilla No. 176206 which I am now sending you. Here I have marked with red the entire portion of the roots that I suppose to be absent in the type. The unmarked portion of the tooth No. 176206 is naturally not exactly like the type of *Hesperopithecus* because the specimens came from representatives of different genera, but the likeness is sufficiently close to make me think that this is the most probable explanation of the type's history.

In Fig. 5 we figure on the left the two gorilla third molars, on the lower one of which Dr. Miller has marked in red the region which he supposes to be absent in the type of *Hesperopithecus;* next to this we show the type of the latter, and at the right above a chimpanzee m^3 in which the postero-external root has been broken off, and below a gorilla m^3 with the same root preserved and distinct from the palatal root. We are, however,

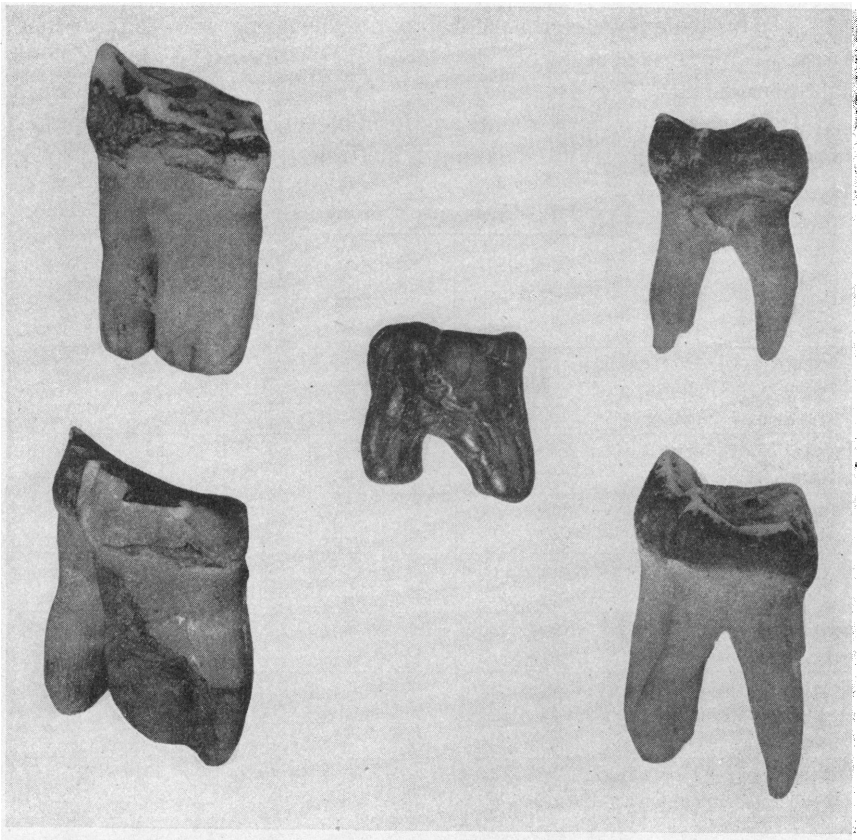

Fig. 5. Comparison of *Gorilla, Hesperopithecus* and chimpanzee molars. Posterior side. × ⅔.

Upper row: *Gorilla*, U. S. Nat. Mus. No. 176212; chimpanzee, A. M. N. H. No. 51394.
Middle row: *Hesperopithecus* type.
Lower row: *Gorilla*, U. S. Nat. Mus. No. 176206; *Gorilla*, U. S. Nat. Mus. No. 174716.

rather inclined to attribute the lack of projecting portions of this root in the type to the same extreme attrition which has smoothed down all other projections of the tooth. We still think that a small portion of the place where the postero-external root forked away from the base of the pulp cavity may be seen; also that the resemblance between the anterior and posterior ridges flanking the median groove is too close for them to have been formed in one case by coalescence with the postero-external root, and in the other case not so. In other words, the evidence suggests to us that the postero-external root was divergent as in certain chimpanzees, gorillas and men (Fig. 5).

The buccal groove on the palatal root, while deeper than in any other tooth we have seen, is feebly developed in certain orang, gorilla, and chimpanzee teeth (Fig. 4).

In short, in the arrangements and form of the roots the *Hesperopithecus* characters are distributed as shown in Table 1.

TABLE I.—COMPARISON OF THE ROOTS

	Hesperopithecus	Orangs	Chimpanzees	Gorillas	*Pithecanthropus*	Men
Forward (+) Intermediate (0) Backward (—) Inclination of Palatal Root to Occlusal Surface	+	—	—	—	—	0 — +[1]
Palatal Root Deeply Grooved on Palatal Side	—	+	+ —	+	—	—
Palatal Root Deeply Grooved on Buccal Side	+	+ —	Usually weak	+ —	—	—
Relative Antero-posterior Diameter of Lingual Root	+	+	—	++	+	+ —
Divergence of Lingual Root from External Roots	+	—	+	+	+	+ —
Relative Transverse Width of Antero-external Root Compared with Palatal Root	—	+	—	+	++	++
Divergence (+) or Confluence (—) of Postero-external with Palatal Root	+	+	+	+ —	+	+

This shows the distribution of agreements and disagreements of root characters to the best of our judgment.

3.—CAN WE SEPARATE THOSE CHARACTERS WHICH INDICATE THE POSITION OF *HESPEROPITHECUS* AS A MEMBER OF THE MAN-ANTHROPOID SERIES FROM THOSE WHICH DISTINGUISH IT FROM THE DIFFERENT GENERA OF THIS GROUP?

(*a.*) The members of the group tend to have an asymmetrical molar crown, but in the anthropoids the transverse diameter of the posterior moiety as compared with that of the anterior moiety is relatively smaller than in modernized man. In this character the type of *Hesperopithecus* conforms rather with anthropoid than with modernized human conditions; but not too much weight should be given to this

[1]The variability is probably revealed by the more abundant material in comparison with that available in the other groups.

character because the enamel shell which covers the outside of the crown is lost in *Hesperopithecus* and this, if present, would alter considerably the appearance of the outer side of the tooth. The resemblances of the crown, as shown in Index 1 of our previous paper, are rather with chimpanzee molars than with human molars.

(*b.*) The great width and flatness of the lingual root distinguish *Hesperopithecus* from the chimpanzee and approach the condition in the gorilla, but in *Hesperopithecus* the palatal surface of the palatal root has at most a very slight vertical groove, while in the gorillas this groove is very large and deep.

(*c.*) In *Hesperopithecus* the transverse diameter of the antero-external root is moderate as compared with the excessive width of this root in man (some gorillas distinctly approach the human condition in the wide transverse diameter of the antero-external root and in the relatively small transverse diameter of the palatal root). In exhibiting the opposite of these characters *Hesperopithecus* is somewhat nearer to the chimpanzee.

(*d.*) The radiographs, aside from showing that the roots and pulp cavity of *Hesperopithecus* conform to the general man-anthropoid type, do not appear to reveal any clear-cut generic characters.

In brief, the more important characters of the *Hesperopithecus* type, the combination of which in one specimen may prove to be generic, are as follows:

(*a.*) Relative antero-posterior diameter of crown of m^2 (?) greater than in men and less than in apes.

(*b.*—Assuming that the *Hesperopithecus* type is an m^2.) The small size of the hypocone, contrasting with nearly all anthropoids and all primitive men.

(*c.*) The more vertical relation of the palatal root to the worn occlusal surface, most nearly approached in certain human teeth.[1]

(*d.*) The deep groove on the buccal side of the palatal root, deeper than any observed in apes or men.

(*e.*) Palatal root probably longer than in men excepting certain Indian teeth and approaching gorilla type.

(*f.*) Transverse diameter of antero-external root relatively smaller than in men and larger than in chimpanzees.

[1]Dr. Miller writes: "Yes, but your Fig. 3 shows that the difference between *Hesperopithecus* and one gorilla is very much less than that between two gorillas."

4.—HOMOLOGY OF THE SECOND SPECIMEN REFERRED TO *HESPEROPITHECUS*

The second specimen (A. M. N. H. No. 17736) of Professor Osborn's original description (*op. cit.*, p. 4) is excessively worn and eroded (Fig. 6) but after prolonged comparisons we are inclined to accept Professor Osborn's provisional determination of it as a third right upper molar. In the contour of the base of the crown it somewhat resembles the third upper molar of a certain chimpanzee (A. M. N. H. No. 51394) but very probably had a longer palatal root.

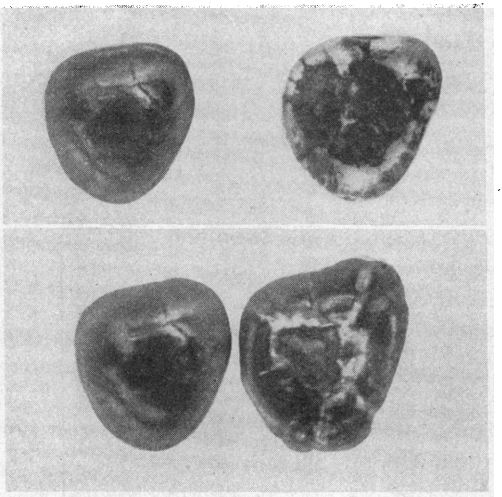

Fig. 6. Second specimen, or paratype, of *Hesperopithecus haroldcookii* compared (upper pair) with m^3 of a chimpanzee and with (lower pair) the type.

5.—*HESPEROPITHECUS* AND *PITHECANTHROPUS*

In our preliminary report on the *Hesperopithecus* molar as cited by Professor Osborn (*op. cit.*, p. 2) we stated that "On the whole we think its nearest resemblances are with *Pithecanthropus* and with men rather than with apes." One of us (M. H.) is still inclined toward this view, while to the other (W. K. G.) it appears that, apart from the relation of the occlusal plane to the palatal root, the prevailing resemblances of the *Hesperopithecus* type are with the gorilla-chimpanzee group.

In our first report we cited the evenly concave wearing surface as a point of resemblance to *Pithecanthropus*. This form of extreme wear is quite common in Indians and Australians, but we have also found it in

a single gorilla (represented by a cast, A. M. N. H. No. 198) while Dr. Miller informs us that he finds a similar condition in a chimpanzee (U. S. Nat. Mus. 174700) also. Hence this character can hardly be taken as diagnostic.

As we recognized at first, the *Hesperopithecus* molar could hardly have supported a hypocone as large as that of the *Pithecanthropus* m^2; it differs also in the transverse narrowness of the antero-external root and in the much smaller antero-posterior diameter of the palatal root.

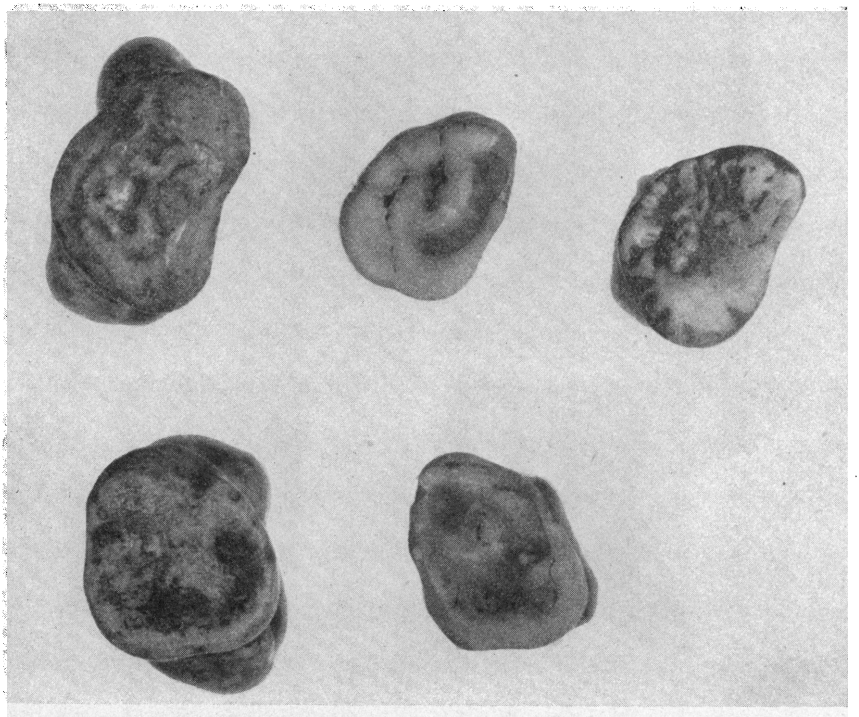

Fig. 7. Comparison of *Pithecanthropus*, Australian and orang molars. × 2.

Upper row: Third right upper molar (cast) referred to *Pithecanthropus;* m^3, right, of Australian aboriginal (A. M. N. H.); m^3, right, of orang, U. S. Nat. Mus. 153805.

Lower row: Second left upper molar (cast) referred to *Pithecanthropus*, m^2, left, of Australian aboriginal (A. M. N. H.).

If the second specimen of *Hesperopithecus* be rightly regarded as an extremely worn m^3 (see above), then the differences of *Hesperopithecus* from *Pithecanthropus* become more emphatic, because the section of the base of the crown of the "second specimen" of *Hesperopithecus* had a prominent postero-external and reduced postero-internal angles and its

crown was relatively long antero-posteriorly and narrow transversely, while the opposites of these features characterize m^3 of *Pithecanthropus*.

The nearer resemblances of the second and third upper molars referred to *Pithecanthropus* appear (Figs. 7, 8) to be rather with the corresponding molars of Australians than with those of apes.[1] They are

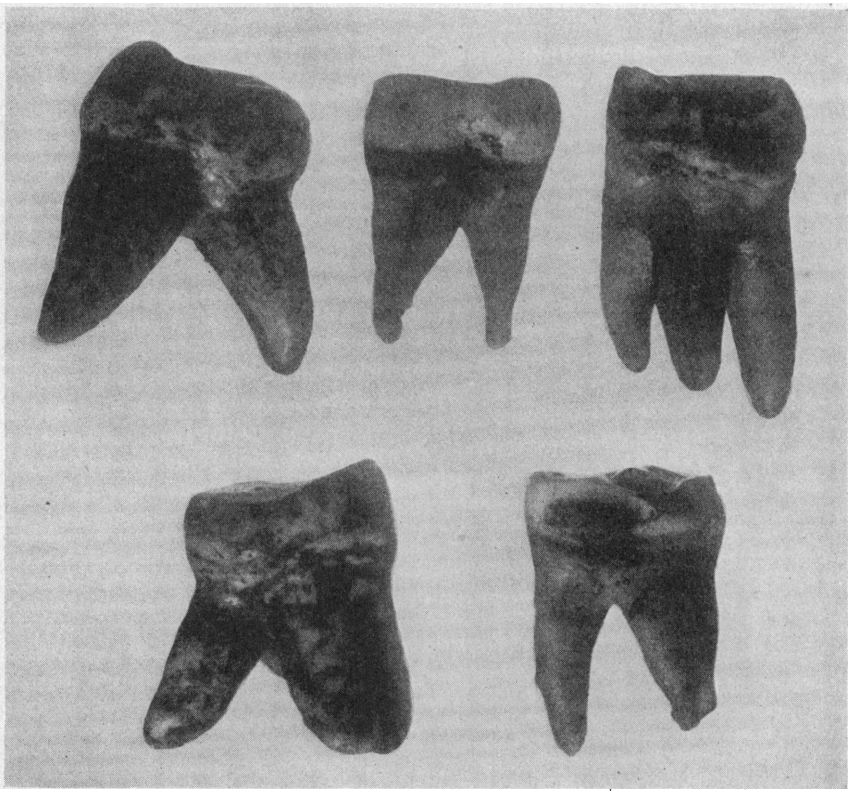

Fig. 8. Comparison of *Pithecanthropus*, Australian and orang molars. Same specimens as in Fig. 7. Posterior (distal) view. × 2.

much larger than those of most Australian aborigines (though smaller than those of the Talgai skull), and have much heavier and more divergent inner and outer roots. The third upper molar differs from the Australian here figured in having a less protuberant hypocone, while in the second upper molar the relative length of the antero-posterior as compared with the transverse diameter is much greater.

[1]Dr. Miller writes: "This statement seems to me much too strong in view of the variation in crown form shown by apes. See especially the orang teeth (m^2) left row sent" (Figs. 14, 15). On this point see the Appendix, below.

6.—*HESPEROPITHECUS* NOT A CARNIVORE

Dr. Smith Woodward still doubts that the type molar of *Hesperopithecus* belongs to a primate and inclines to regard it as one of the primitive extinct bears (*Hyænarctos*).[1] Dr. Matthew, who has had exceptionally long and wide experience in studying the teeth of fossil and recent carnivores, has endorsed the judgment of Professor Osborn that the tooth is not that of a carnivore. One of us (W. K. G.) has repeatedly searched the Museum collections of carnivores for further evidence bear-

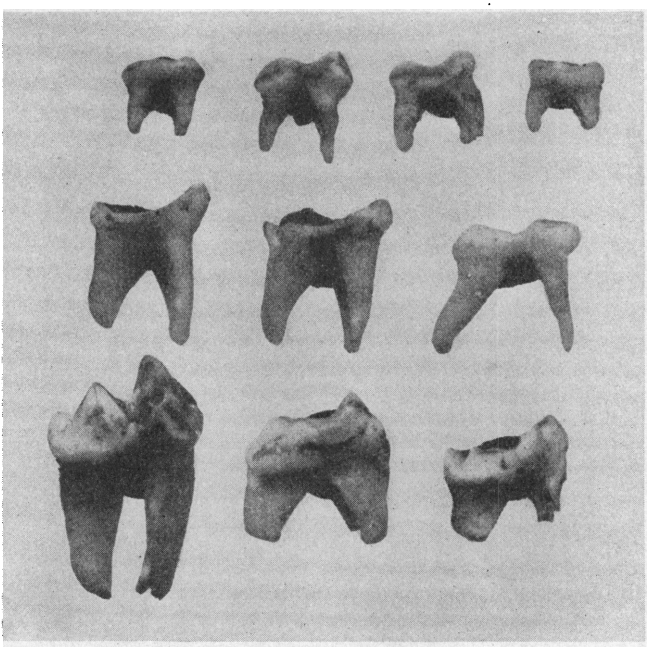

Fig. 9. Upper molars of modern carnivores. Distal, or rear, view. × 2.

Upper row: *Bassaricyon osborni* m^2, A. M. N. H. No. 32609; ditto, m^1; *Cercoleptes* (*Potos*) *flavus* m^1, A. M. N. H. No. 15475; ditto, m^2.

Middle row: *Nasua* sp. m^3, A. M. N. H. No. 35453; ditto, m^2; *Viverra zibettha* m^1, A. M. N. H. No. 91.

Lower row: *Ælurus fulgens*, m^1, A. M. N. H. No. 32650; *Procyon lotor*, m^2, A. M. N. H. No. 8335; *Mephitis* sp. m^1, A. M. N. H. No. 77.

ing on the problem. First, comparing the *Hesperopithecus* type with carnivores in general, we find: (1) In the upper molars of carnivores of all known families the vertical distance from the middle of the occlusal surface to the bottom of the pulp cavity, where the inner and outer roots fork, is proportionately much less than in *Hesperopithecus* (Figs. 8, 9, 13).

[1]Nature, November 25, 1922, CX, p. 707.

In other words, the latter molar is not nearly so brachyodont, but has a vertically deeper pulp cavity, as in apes and men, its apparent brachyodonty being due both to extreme natural wear and to the rounding and attrition of the enamel borders. (2) In typical carnivores (Fig. 9) the two outer roots are relatively slender and separated widely from each other and from the inner root. (3) The antero-external root is usually narrower transversely, less compressed antero-posteriorly, and more conical than

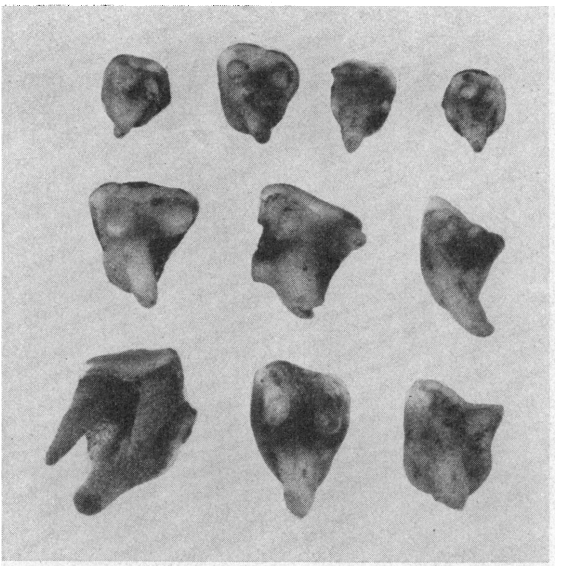

Fig. 10. Upper molars of modern carnivores. Viewed from above, showing roots. × 2. Same specimens as in Fig. 9.

in *Hesperopithecus*. (4) The palatal, or inner, root of carnivores is often more widely divergent from the outer roots, is not flattened on the palatal surface, is not deeply grooved on its buccal side and is relatively shorter and more pointed apically. (5) In these carnivore molars which have a hypocone it juts obliquely backward and inward, and the crown at its base is relatively wider than in *Hesperopithecus*.

Secondly, comparing the *Hesperopithecus* type molar with those of *Hyænarctos* and other ursids (Figs. 11, 12, 13), we find that some of the modern ursids depart from the normal carnivore type described above, in the following respects: (1) The palatal root (Fig. 12) becomes excessively wide, far wider than in *Hesperopithecus*, and (2) it exhibits a

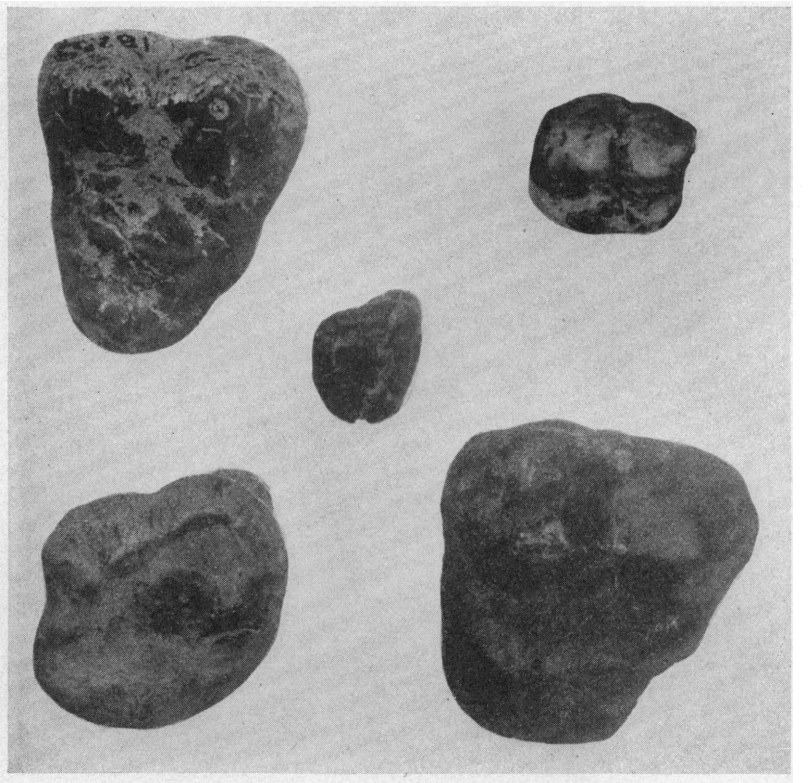

Fig. 11. Comparison of *Hesperopithecus* molar with *Hyænarctos* and other ursoid carnivore molars. Occlusal view. × ⅔.

Upper row: *Amphicyon sinapius*, A. M. N. H. No. 18259, Lower Snake Creek beds (Upper Miocene); *Ursus malayanus*, A. M. N. H. No. 296.

Middle row: *Hesperopithecus* type. Upper Snake Creek beds (Lower Pliocene).

Lower row: *Indarctos* (?) sp., Upper Snake Creek beds (Lower Pliocene), Coll. H. J. Cook; *Hyænarctos gregoryi*, Univ. Calif. No. 24025, Eden beds (Pliocene).

tendency to divide into anterior and posterior moieties; (3) as a consequence, the buccal side of the palatal root exhibits a prominent vertical groove; (4) at the same time the antero-external (mesio-buccal) root becomes widened transversely. But these points of partial agreement, either with *Hesperopithecus* or with other anthropoids, are at once seen to be analogies and not homologies indicative of close relationships, first, by reason of the wide dissimilarity of the ursid and *Hyænarctos* molar crowns to that of *Hesperopithecus* and other anthropoids and, second, because the *Hesperopithecus* molar crown and roots differ totally from the PRIMITIVE carnivore types as described above, while the ursid and *Hyænarctos* crowns and roots are as clearly derived from it.

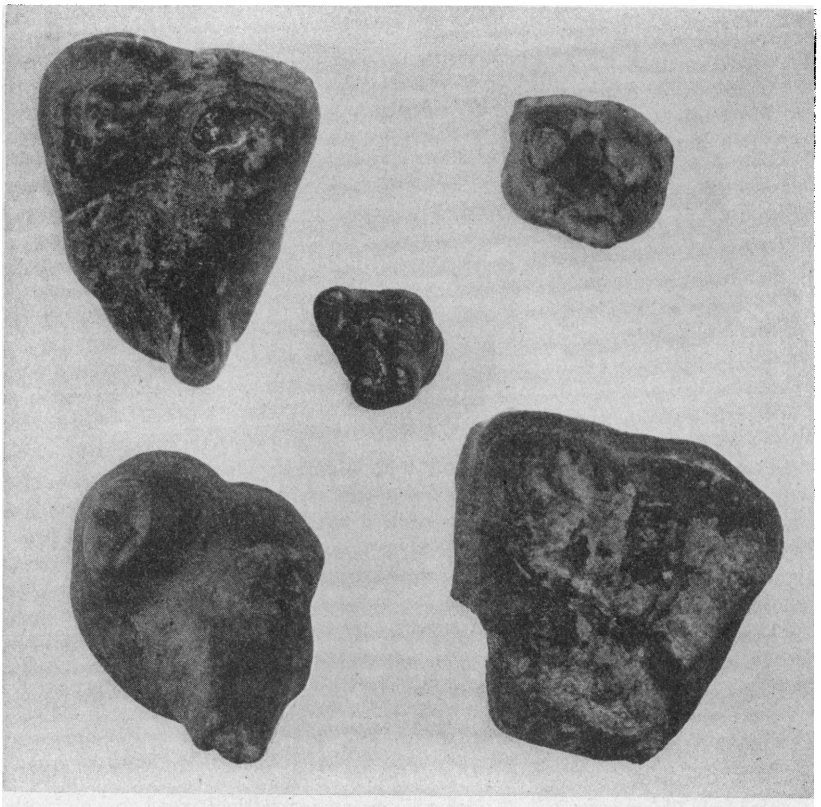

Fig. 12. Comparison of *Hesperopithecus, Hyænarctos,* etc. (continued). Same specimens as in Fig. 11, viewed from above. × ⅔.

In conclusion, the profound differences of the *Hesperopithecus* tooth from that of carnivores throws into stronger relief its numerous and fundamental points of agreement with those of the ape-man group of the primates.

CONCLUSIONS

1.—The question whether the type of *Hesperopithecus* is a third upper molar or a second is still open but we incline to the view that it is a second.

2.—The greater number of resemblances of the type appear to be with gorilla and chimpanzee rather than with orang. One of us (M. H.) still regards the human resemblances as being of considerable signifi-

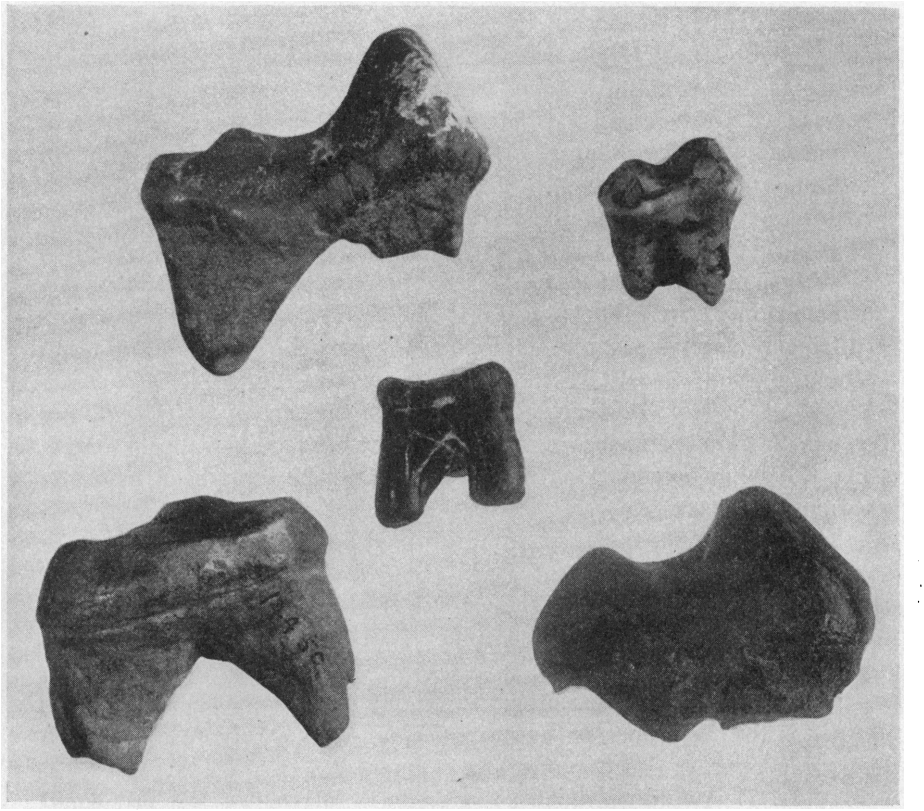

Fig. 13. Comparison of *Hesperopithecus*, *Hyænarctos*, etc. (continued). Same specimens as in Figs. 11 and 12. Mesial or anterior view. × ⅔.

cance, while the other (W. K. G.) leans toward the anthropoid affinities of the type. The range of variability in crown and root characters of the molars both in the Hominidæ and the Simiidæ is so great and so overlapping as to warrant either interpretation.

3.—In view of the foregoing, the exact generic diagnosis of *Hesperopithecus* must await further discoveries.

4.—The paratype, or second specimen, of *Hesperopithecus* is pretty surely an upper molar and is probably a third.

5.—The second and third upper molars found near the *Pithecanthropus* skull top approach those of an Australian aboriginal here figured, but are even closer to those of certain orangs selected by Doctor Miller (see Appendix), especially in the roots. We cannot, however, accept

unreservedly his conclusion that the teeth referred to *Pithecanthropus* are probably those of a now extinct Javan great ape, representing the orangs of Sumatra and Borneo. Striking as these resemblances are, the fact should not be dismissed that the third molar was found in apparent association[1] with a cranium and femur of unquestionably human, or subhuman, type, and in the lack of additional evidence we think it profitless to assume that the teeth do not belong with the skull. The peculiar contraction of the occlusal surface and the orang-like crenation of the enamel of the *Pithecanthropus* m^3 is well shown in the molars of a certain Bantu negro (A. M. N. H. No. D 7), while other features (jutting hypocone, sloping ectoloph, etc.) may be matched in other human teeth.

6.—Professor Osborn's determination of the type of *Hesperopithecus* as a new genus of anthropoid apes has not been universally accepted. The following possible identifications of the type have been made by various persons.

(1) Upper molar of an anthropoid ape, probably a new genus (American Museum staff).

(2) Lower molar of *Hyænarctos* or allied genus of ursid.

(3) Upper molar of the same.

(4) A "bear's tooth."

(5) A molar of an otherwise wholly unknown type of carnivore.

(6) An upper or lower molar of some carnivore allied with *Æluropus*.

(7) An upper molar of a gigantic relative of the procyonid canivore *Potos*.

(8) An upper molar of a gigantic relative of such South American monkeys as *Pithecia* and *Lagothrix*.

(9) The first upper deciduous premolar of a Pliocene horse.

(10) An incus bone of a gigantic mammal.

We have considered each of these with unbiased minds and compared the type with the various specimens suggested, as well as with many others, but have returned with more confidence to the conclusions set forth above (Nos. 1 to 4).

---

[1]According to Dubois (1894, pp. 2, 3) the calvarium was found only one meter distant from the site of the third molar and in the same plane. In this connection Dr. Miller writes: "In publishing anything about the Javan teeth I particularly wish to avoid all discussion of the bones. The latter I have never examined critically, and I have so many other things on hand that I do not wish to become interested in a subject which I can foresee would be more than absorbing. About the teeth, however, I am very glad to place my opinion on record."

APPENDIX.—NOTES ON THE CASTS OF THE *PITHECANTHROPUS* MOLARS[1]

By Gerrit S. Miller, Jr.

Whatever the bones may prove to be, I think that the molars referred to *Pithecanthropus* are probably those of a now extinct Javan great ape representing the orangs of Sumatra and Borneo. Whether or not this ape was strictly congeneric with the orangs I am not prepared to say, because the teeth, like those of *Hesperopithecus*, are neither in sufficiently good condition nor in sufficiently great number to show what the animal's dental characters really were; but, so far as they go, they come almost within the limits of individual variation of the living orangs, and in the slight peculiarities where they differ from orangs they do not approach men. Hence I think it is entirely misleading to speak of your fossil as showing resemblances "with *Pithecanthropus* and men rather than with apes" (your p. 12).

Here is my evidence and I shall be interested to know what you think of it.

(*a.*) The Second Upper Tooth.—Compare the cast with orangs (Fig. 14 *a-d*) Nos. 142170 (*a*), 142197 (*b*), 145304 (*c*), and 153808 (*d*). These four specimens seem to me to cover all the essential features of the cast. They show more tendency for the crown to swell out beyond the level of the roots along the anterior border, and less to swell out in the region of the hypocone; but I should hesitate to regard this as anything more than an individual character unless it were known to be constant in many teeth. The peculiar form of the roots in the cast is very nearly duplicated in No. 145304 (Fig. 15 *a*, *i*). Notice in this connection the striking difference in root form which exists between Nos. 145304 (Fig. 15 *a*, *i*), and 142197 (Fig. 15 *c*, *k*); it is much greater than that between 145304 and the cast (*b*, *j*). The other specimens (Fig. 14 *e*-k) are sent to show the range of variation in m^2. Compare 153822 (Fig. 14 *g*) and 142185 (Fig. 14 *e*) for difference in length-breadth ratio; 142197 (*b*) and 153816 (*h*) for difference in size of two males; 153822 (*g*) and 142185 (*e*) for difference in development of hypocone (that this is not a sexual character is shown by the large hypocone in No. 153824 (*j*)); Nos. 153808 (*d*) and 153822 (*g*) for difference in development of paracone and metacone and of the sulcus between them; No. 145322 (*q*) for a peculiar narrowing of the area of wrinkled enamel. After examining all of these

[1]Excerpts from two letters from Gerrit S. Miller, Jr. to W. K. Gregory; published here with Dr. Miller's kind permission. The orang molars illustrated in Figs. 14, 15 were loaned by the U. S. National Museum. For these courtesies and for Dr. Miller's unfailing coöperation the authors desire to express their gratitude.

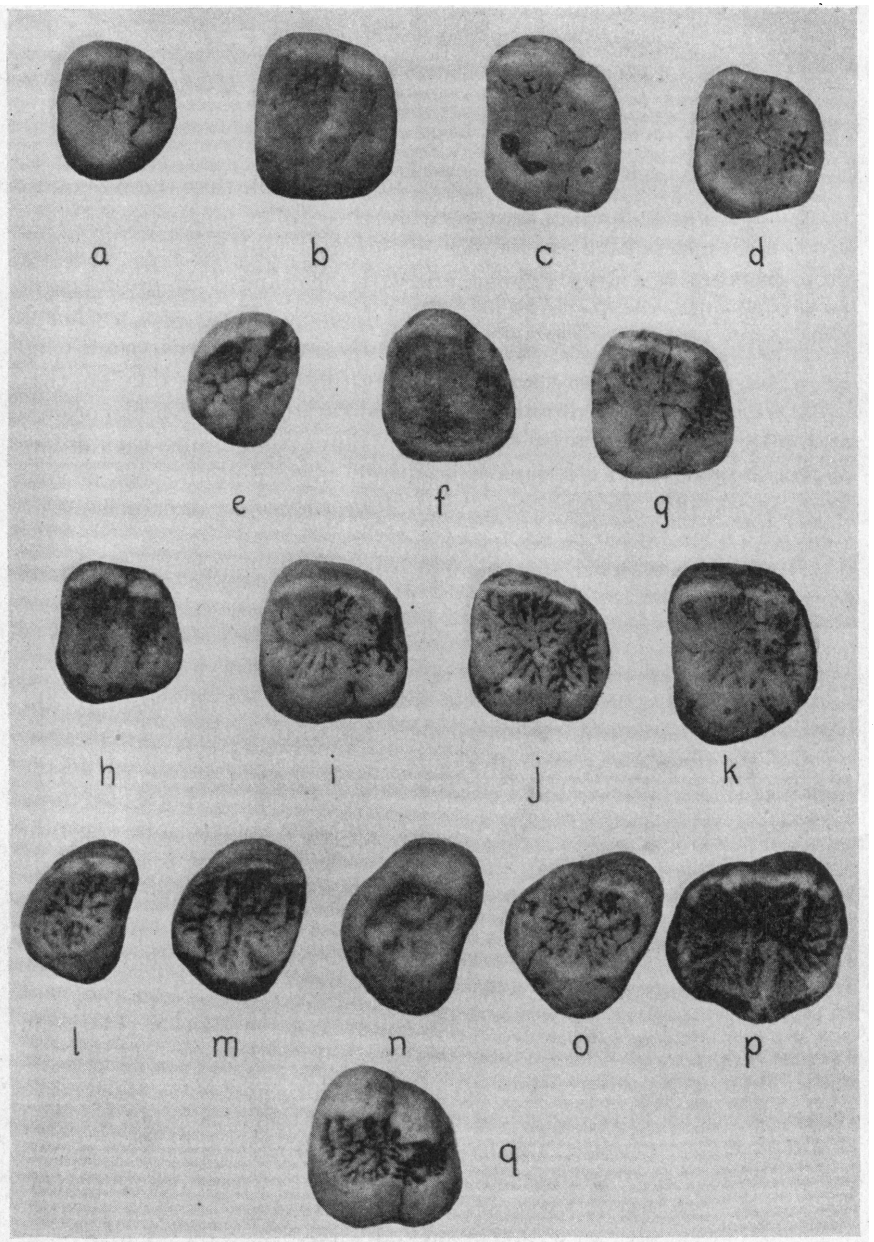

Fig. 14. Comparison of *Pithecanthropus* and orang molars. Occlusal view, × 3/2. Second upper molars:

a—U. S. N. M. 142170; *b*—142197; *c*—145304; *d*—153808; *e*—142185; *f*—*Pithecanthropus*; *g*—153822; *h*—153816; *i*—49856; *j*—153824; *k*—145307.

Third upper molars:

l—142191; *m*—142169; *n*—*Pithecanthropus*; *o*—153806; *p*—142181; *q*—145322.

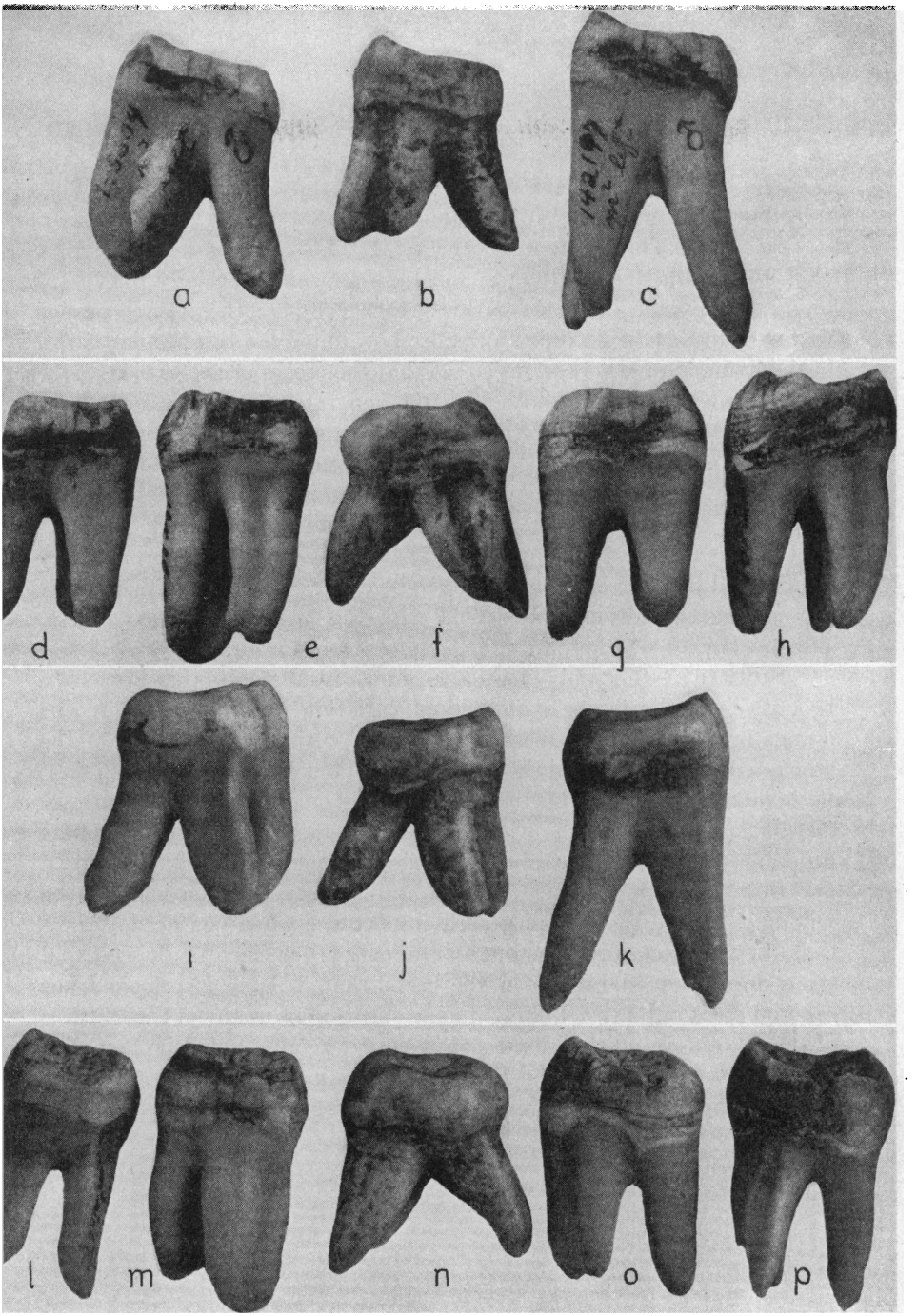

Fig. 15. Comparison of *Pithecanthropus* and orang molars continued. × ¾.

Anterior view, second upper molar:
a—145304; *b*—*Pithecanthropus*; *c*—142197.

Anterior view, third upper molar:
d—142191; *e*—142169; *f*—*Pithecanthropus*; *g*—153806; *h*—142181.

Posterior view, second upper molar:
i—145304; *j*—*Pithecanthropus*; *k*—142197.

Posterior view, third upper molar:
l—142191; *m*—142169; *n*—*Pithecanthropus*; *o*—153806; *p*—142181.

can you show me any character in the cast that you would be willing to call generic on the basis of one tooth?

(*b*.) The Third Upper Tooth. (Fig. 14 *l-p*).—Compare the cast (Fig. 14 *n*) with Nos. 142169 (*m*) and 142191 (*l*) and especially 153806 (*o*) for near approach in crown outline; then compare these three orangs with No. 142181 (*p*) in order to realize how much the third molar varies in the living animal. It seems to me that the crown of the cast is easily interpreted as an orang tooth with the general form of No. 153806 (*o*) plus a slight tendency toward reduction of the wrinkled area like that shown by m^2 No. 145322 (Fig. 14 *q*). The roots are not quite so easily dealt with. I cannot find any recent specimen in which they exactly agree with those in the cast, particularly as regards their angle of divergence; but in No. 142191 (Fig. 15 *l*) the two outer prongs are partly joined, and this process would need to be carried only a little farther (as the joining of the postero-external with the lingual is carried in No. 142169 (Fig. 15 *m*) to produce the conditions seen in the cast.

Summary.—The only characters shown by the casts that appear to be outside of the limits of individual variation in our series of recent orangs are: (*a*) in both teeth a tendency for the posterior side of the crown to bulge out beyond the level of the roots (nearly realized in 145322); (*b*) in m^2 the absence of this tendency to bulge outward along the anterior margin; and (*c*) in m^3 the wider angle of divergence of the roots. These differences point to a probable specific distinctness of the extinct Javan ape from the living ones of Borneo and Sumatra; but would you be willing to regard them as of generic importance when you do not know that they are actually constant in the extinct species; or do you find some important characters in the casts that I have overlooked; or can you point out any definitely human suggestions in any of the features of the casts? In all this discussion we must keep in view the fact that it is only with casts of the *Pithecanthropus* molars that we are now dealing; the actual teeth may show features which will cause us to change our minds.