ence in P 3/. "Third and fourth upper premolars with tetartocone spurs united chiefly with protoloph"—(Osborn, 1898). In *Subhyracodon occidentale,* on the other hand, P 3/ has its protoloph and metaloph approximately parallel and partly separate, with an internal outlet for the median valley. *Subhyracodon copei* differs from *Subhyracodon trigonodum* in the pattern of both P 3/ and P 4/, where the outlet of the valley is median.

There are two specimens referred to *Subhyracodon copei,* A. M. N. H. Nos. 6326 and 12452, from the Upper Titanotherium Beds.

The closest relationships of *Subhyracodon copei* are with *Subhyracodon occidentale,* to which, as Osborn has pointed out (1898), it is in all probability ancestral. Increase in size, earlier loss of C 1/ and a slight advance in P 3/ are the chief advances necessary to give the later form.

Subhyracodon occidentale (Leidy) 1854 Pl. XII, Leidy, 1854 a

Rhinoceros occidentalis Leidy. Leidy, 1850. Proc. Phil. Acad. Nat. Sci., V, p. 119. This is a nomen nudum, as the type is lost and would, in any case, be indeterminable.
Rhinoceros occidentalis Leidy. Leidy, 1854 a.
Aceratherium occidentale (Leidy). Leidy, 1854 b.
Aceratherium (*Subhyracodon*) *occidentale* (Leidy). Brandt, 1878.
Aceratherium occidentale (Leidy.) Cope, 1879 a.
Aceratherium occidentale (Leidy). Osborn, 1898.
Cænopus occidentalis (Leidy). Osborn, 1900.
Cænopus (= *Subhyracodon*) *occidentalis* (Leidy). Osborn and Matthew, 1909.
Cænopus trigonodus allus Troxell. Troxell, 1921 a.
Cænopus copei Troxell (not Osborn) in part. Troxell, 1921 a.
Aceratherium occidentale (Leidy). Osborn, 1923 a.

I agree with Osborn (1898) and Sinclair (1924) that *S. occidentale* is valid, in preference to Troxell's opinion (1921) that it should be abandoned in favor of *S. copei.*

The neotype is U. S. National Museum No. 114. The range of this species is probably the Lower and Middle Oreodon Beds. This animal was slightly larger in nearly all dimensions than *Subhyracodon copei.* The molar series is markedly longer than in *Subhyracodon copei.* The premolar series is distinctly shorter than in *Subhyracodon metalophum* and less advanced (especially P 4/). Its inferiority in size as compared with *Subhyracodon tridactylum* is still more apparent.

There are no traces of horn cores. The manus is tridactyl. I 2/2, C 0/0, P 4/3, M 3/3. d I 2/2, d C 0/0, d P 4/4. I 2/ is still large. P 2/ has parallel, separate lophs. P 3/ has its protoloph and metaloph fully confluent after slight wear but the hypocone is better developed than in *Subhyracodon trigonodum* and, unlike *S. copei,* the outlet of the valley is median. The metaconule of P 4/ usually turns anteriorly and abuts against the outer side of the hypocone, which is only partly distinct from the protocone. The median valley usually escapes posteriorly (much like P 3/ of *Subhyracodon copei*) until a moderately advanced stage of wear. I /2 is semi-erect.

The character of P 4/ before excessive wear is well shown in A. M. N. H. No. 6330, collected by Cope in Colorado in 1873, in the White River Beds. These teeth show clearly the original pattern of the type specimen before it was greatly worn. (See Pl. XII, Leidy, 1854 a.) It is also well shown in A. M. N. H. No. 1113, collected by the A. M. N. H. Expedition of 1894, from the "Turtle-Oreodon Layer," Oreodon Beds, Cheyenne River, South Dakota, a specimen younger than the type of *Subhyracodon copei,* about the age of the type of *Subhyracodon trigonodum,* for M 3/ is not quite fully erupted. P 3/ has its metaloph already complete, united to the protoloph and completely enclosing the median valley. P 4/, very slightly worn, shows a posterior outlet for the median valley between the hypocone and the metaconule.

The specimen which Koch (figured by Koch, 1911 and Abel, 1914) referred to *Præaceratherium minus* seems distinct from the type. On the other hand, both in size and dental characters, it seems so like *Subhyracodon occidentale,* that if it had been found in North America, it would have been referred to that species.

Subhyracodon occidentale (Leidy)

Cænopus trigonodus altus Troxell. Troxell, 1921 a (figs. 1 and 2).

The holotype is Y. P. M. No. 12052, from the Oreodon Beds of Nebraska, collected by Mr. H. C. Clifford. This is a young individual. The third right upper molar was just about to erupt, as were both third lower molars.

I fail to see any marked resemblance between this specimen and the type of *Subhyracodon trigonodum*. It does not have the one really distinctive feature of the latter species, the confluent protoloph and metaloph on P 4/, forming a V with a median outlet for the valley, nor the somewhat loose attachment of the hypocone to the metaconule, notched by a deep valley posteriorly, on P 2/. In size, loss of C 1/, and general character, it resembles *Subhyracodon occidentale*.

The figures in Troxell's paper are accurate, except that they fail to show a small antero-internal descending rib, between the protoloph and ectoloph of P 1/ and the "mure" connecting the protocone and hypocone of P 2/.

Subhyracodon gidleyi, new species Figs. 29, 30, 31

The holotype, U. S. N. M. No. 11337, was collected by Mr. J. B. Hatcher in 1886, from the "White River Tertiary." It is slightly smaller than the type of *Subhyracodon occidentale*, from which the premolars are indistinguishable. The name is given for Dr. J. W. Gidley. M 1/ and M 2/ have part of the median valley completely cut off by the upgrowth of the antecrochet, to form medifossettes.

The specimen consists of left P 2/–M 2/, with the roots of P 1/ and fragments of M 3/, and right P 4/–M 2/, with the roots of P 1/–P 3/ and the front half of M 3/, fragmentary lower teeth, and the astragalus. Associated with it are *Mesohippus* and *Oreodon* teeth.

P 1/ had two roots. P 2–4/ have complete internal cingula. P 2/ has the protoloph and metaloph separate and parallel, but connected well above the level of the cingulum. P 3/, rather worn, has the same character as the type of *S. occidentale*—or of most other members of the genus after a corresponding amount of wear. P 4/ has the character of *S. occidentale* or *S. copei,* in that the hypocone is a bud from the protocone, and the metaconule joins its anterior end. The molars have incomplete internal cingula. M 1/ is well worn. It has a medifossette completely cut off by the antecrochet. The internal cingulum, absent from the inner slopes of the two lophs, is very strongly developed across the valley, forming a dam of considerable height. M 2/ has no internal cingulum, except a slight one on the protocone, which does not close off the median valley. The antecrochet cuts off a deep medifossette. There is a faint trace of a crochet on the left side, but none on the right. The protocone of M 3/ interrupts the cingulum internally. There is a trace of the posterior buttress, and a distinct post-fossette. The molars have no external cingula, except a faint trace on the paracone of M 1/, and an extension along the ectoloph of M 3/ external to the posterior buttress.

The lower teeth are in very fragmentary condition, but they show unusually heavy cingula. Right P /2 is completely surrounded by a cingulum, except for a short space posteriorly. Left P /3 is almost completely surrounded by a cingulum, except for short interruptions by the metaconid and entoconid. The anterior, posterior, and external valleys are definitely enclosed at their feet. Right M /1 has a cingulum extending from the paraconid onto the metaconid, enclosing the anterior valley, and another from the metaconid to the entoconid, blocking the posterior valley.

The level of this form is not known. It gives a surprising mixture of characters, since the premolars are indistinguishable from *Subhyracodon occidentale,* and the molars, by themselves, would probably be referred to a new species of *Diceratherium* (in the restricted sense). It seems quite possible that the explanation of this apparent discrepancy lies in the field of genetics, rather than of paleontology.

Subhyracodon metalophum (Troxell) 1921

Aceratherium occidentale (Leidy). Osborn, 1898 (A. M. N. H. No. 1123, Pl. XIII, Fig. 1).
Cænopus tridactylus metalophus Troxell. Troxell, 1921 a (fig. 4).

"Holotype, No. 10245, Y. P. M. Probably Middle Oligocene, Rushville, Nebraska." Another specimen virtually identical with this, A. M. N. H. No. 1123, from the Upper Oreodon Beds, collected by American Museum Expedition of 1894, was described and figured by Osborn (1898). This form was larger than *Subhyracodon occidentale*, smaller than *Subhyracodon tridactylum* and probably hornless in both sexes. I 2/?, C 0/?, P 4/?, M 3/?. I 2/ is still large. The protoloph and metaloph of P 4/ are separate and parallel. The upper molars are smaller individually and collectively than in *Subhyracodon tridactylum* and have no secondary folds.

Osborn regarded this form as an advanced evolutionary stage of *Subhyracodon occidentale*, whereas Troxell considered it a primitive sub-species of *Subhyracodon tridactylum*. It is probably simplest to raise it to specific rank, and this would seem to be justified by its difference in character and level. Both stratigraphically and morphologically, it succeeds the typical *Subhyracodon occidentale*, and precedes the typical *Subhyracodon tridactylum*. Morphologically, it is also possible to derive it from *Subhyracodon trigonodum*. Stratigraphically, either form would answer equally well as an ancestor.

Y. P. M. No. 10254 has no trace of a mure on the upper premolars. In A. M. N. H. No. 1123, however, there is a mure on both P 4/'s, and on right P 2/ (omitted in Osborn's figure, 1898), but no trace of it on left P 2/.

The Effects of Wear in Subhyracodon

An old *Subhyracodon copei* would assume the same pattern as an old *Subhyracodon occidentale.* A worn *Subhyracodon trigonodum* would be less easily distinguishable from a worn *Subhyracodon occidentale.* It would, however, never become absolutely identical with it, for P 4/ of the former would always have the protoloph and metaloph forming a blunted V, whereas, in the latter, the metaconule would always hook on to the antero-external edge of the hypocone, so that the hypocone projects backward beyond the metaconule, although the extent to which it projects is progressively reduced by wear. A worn *Subhyracodon occidentale* may become indistinguishable from a worn *Subhyracodon metalophum,* and vice versa.

There is no reason to confuse the unworn pattern of any of the four species with any of the others.

Subhyracodon Brandt 1878

Anchisodon Cope 1879

The genoholotype is *Aceratherium quadriplicatum.*

Subhyracodon ? quadriplicatum (Cope) 1873

Hyracodon quadriplicatus (Cope) 1873
Aceratherium quidriplicatum (Cope). Cope, 1875.
Aceratherium (Subhyracodon) quadriplicatum (Cope). Brandt, 1878.
Anchisodon quidriplicatus (Cope). Cope, 1879.
Aceratherium quadriplicatum (Cope). Matthew, 1899.
Anchisodon quadriplicatus (Cope). Osborn and Matthew, 1909.

The holotype, A. M. N. H. No. 6339, from the (? Upper) Oreodon Beds, Cedar Creek, Logan County, Colorado, was collected by Professor Cope in 1873. It consists in the first and second left upper deciduous premolars and the first, second, and third right upper deciduous premolars. They are probably referable to some member of the genus *Subhyracodon,* even as here restricted, and, more likely than not, to *Subhyracodon occidentale* or *metalophum,* but they are not certainly determinable. The genus is regarded tentatively as a synonym of *Subhyracodon,* and the species as indeterminable.

Subhyracodon tridactylum (Osborn) 1893
Pl. XIII, fig. 8, and Pl. XVII, Osborn, 1898

Aceratherium tridactylum Osborn. Osborn, 1893.
Diceratherium proavitum Hatcher. Hatcher, 1894.
Aceratherium tridactylum Osborn. Osborn, 1898.
Cænopus tridactylus (Osborn). Osborn and Matthew, 1909.
Cænopus tridactylus (Osborn). Troxell, 1921 a.
Cænopus tridactylus proavitus (Hatcher). Troxell, 1921a.
Diceratherium tridactylum (Osborn). Osborn, 1923, b, p. 215.

The holotype is A. M. N. H. No. 533, a skull and nearly complete skeleton, collected by the Expedition of 1892, from the Protoceras Beds of South Dakota. Incipient horns are present in the males. I 2/2, C 0/0, P 4/(4)–3, M 3/3. I 2/ is small. The protoloph and metaloph of P 4/ are separate and parallel Secondary wrinkles may appear on M 1 or M 2/. I 2 is semi-erect to semi-procumbent. This species differs from *Subhyracodon metalophum* in its horizon, larger size, the presence of incipient horns on the male, greater length and width of the upper molars, occasional greater complication of the pattern of the upper molars, and the more frequent development of incipient mures on the upper premolars.

The type skull has an alveolus for the third left lower incisor and the first right lower premolar. The occasional presence of four lower premolars is almost certainly due to the abnormal retention of d P /1, a very small tooth, agreeing with what is unquestionably d P /1 in calves of *Subhyracodon occidentale* and *Subhyracodon tridactylum*. This tooth is both smaller and simpler than the P /1 (or possibly d P /1) of *Trigonias osborni* and *Trigonias ? gregoryi*. A calf lower jaw of *Subhyracodon tridactylum*, A. M. N. H. No. 1112, from the Protoceras Beds, has the formula I /2, C /0, d P /4 (M /1 just about to erupt). The alveolus for d P /1, which has dropped out, measures 12 x8.5 mm.

Osborn's original description is incorrect in two points. The union of the post-glenoid and post-tympanic processes in the type skull is apparently due to crushing. And, as Peterson pointed out (1911), the statement "no trace of fifth digit" is inexact, as the same nubbin representing metacarpal V, with its facet on the unciform, is present, as in *Subhyracodon occidentale* and *Menoceras cooki*.

If *Subhyracodon tridactylum* were transferred to the genus *Dicatherium*, as was done by Osborn (1923 b), it would have the advantage of making the latter genus nominally, as well as actually, monogenetic (see Miller, 1923, for definition of this term), according to the phyletic tree suggested below. However, it does not seem desirable to transfer a species to a different genus on quite such a slim basis, and this species really agrees more closely with *Subhyracodon occidentale,* the type of its genus, than with *Diceratherium armatum,* the type of the succeeding genus.

U. S. N. M. No. 11340 is apparently referable to this species, although it is very small, agreeing in size with the type of *S. occidentale.* Its red matrix suggests strongly that it came from the Oreodon Beds, but its level and exact locality were not recorded.

Diceratherium Marsh 1875

The genoholotype is *Diceratherium armatum* Marsh, Y. P. M. No. 10003, from the Lower John Day of Oregon. These were large Miocene rhinoceroses with paired horn cores on the nasals in the males, the females being hornless or nearly so. The horn cores are antero-posterior ridges, near to, but not on the ends of the nasals, and not knob-shaped. The upper cheek teeth are simple in pattern for Miocene rhinoceroses, with relatively few secondary crests and folds. A mure frequently ocurs on the upper premolars.

The splitting off of *Menoceras* Troxell as a separate genus from *Diceratherium* Marsh .is here tentatively accepted. The splitting off of *Metacænopus* Cook from *Diceratherium,* on the basis of sex characters, seems totally unwarranted, and *Metacænopus* (Cook, 1909) is here considered as congeneric with *Diceratherium.*

The following species seem to be quite certainly valid:
Diceratherium armatum Marsh — John Day and Great Plains
Diceratherium annectens (Marsh)—John Day
Diceratherium cuspidatum Troxell—John Day
Diceratherium lobatum Troxell—John Day
Diceratherium niobrarense Peterson—Great Plains
Diceratherium avum (Troxell)—Great Plains.

Y. P. M. No. 10235, "*Diceratherium* cf. *armatum*," from the Upper Oligocene, North Fork of the White River, collected by Mr. H. C. Clifford, resembles *Diceratherium armatum* so closely that there does not seem to be any reason against referring it definitely to that species. The only appreciable difference is the presence of a mure on P 4/, which is absent in the John Day form.

What seems the most plausible view of the interrelationships of the different species is given in the phyletic tree near the end of this paper.

Diceratherium avum (Troxell) 1921

Cænopus tridactylus avus Troxell. Troxell, 1921 a (fig. 5).

The holotype is Y. P. M. No. 10251, collected by Mr. Brown from the Protoceras Beds of South Dakota. The animal was slightly larger than *Subhyracodon tridactylum*. There is a mure on P 2/ and P 3/. M 1/ and M 2/ have a crochet running from the metaloph which cuts off part of the median valley, giving an enclosed basin, as in *Subhyracodon gidleyi*, although smaller and arising in a different way.

This form was described and figured by Troxell, who regarded it as an advanced subspecies of *Subhyracodon tridactylum*. It seems sufficiently advanced over that form to deserve specific rank. Its greater size and the increasing complexity of the cheek teeth make it seem preferable to include it tentatively in *Diceratherium*. The intergradation of the two genera is so close, that any line of separation is rather arbitrary.

Diceratherium ? persistens (Osborn) 1904

Cænopus persistens Osborn. Osborn, 1904.

The type of this species is A. M. N. H. No. 9081, collected from the Miocene of Logan County, Colorado, by the Expedition of 1893.

This animal was probably a female dicerathere. The teeth are so worn that any specific determination would be highly questionable.

Paracænopus Breuning 1923

Genoholotype: *Præaceratherium filholi* (Osborn).

Aceratherium filholi Osborn. Osborn, 1900.
Præaceratherium filholi (Osborn). Abel, 1910.
Acerotherium filholi Osborn. Roman, 1912.
Paracænopus filholi (Osborn). Breuning, 1923.

The most useful figure of this species, in addition to Osborn's (1900), is published by Abel (1914). It shows the premolars in exactly the stage of evolution of *Subhyracodon occidentale,* with, however, a well-marked remnant of the posterior buttress on M 3/.

Breuning refers this genus to a new subfamily, the Cænopinæ. The closest resemblances of this genus would seem to be with *Subhyracodon* or with *Amphicænopus,* new genus, judging by the published figures. If it is eventually held to be congeneric with the former, it becomes, of course, a synonym. If it is congeneric with the latter, it takes precedence. That it is generically distinct from both is still another possibility.

Amphicænopus, new genus

The genoholotype is *Aceratherium platycephalum* Osborn and Wortman. This genus consists of very large, unprogressive Oligocene rhinoceroses, extending from the Titanotherium Beds to the Protoceras Beds. They are hornless in both sexes. The manus is unknown. P 3/ resembles *Trigonias gregoryi,* with the median valley escaping posteriorly. The internal cingulum on the premolars is complete, but, relatively, slightly weaker than in members of the genus *Subhyracodon,* as here restricted. The internal cingulum on the upper molars is altogether absent, or very weak. When present, the chief trace surrounds the protocone of M 3/. A trace of the posterior extension of the ectoloph appears rather frequently on M 3/. I /2 is procumbent. This genus shows its closest relationships to *Trigonias*, especially to *Trigonias paucidens*, and through it, to *Trigonias osborni* (see above). It seems probable that these two species are in its ancestral line. C 1/ is the first upper tooth to be lost, in this line.

This genus, as suggested by Osborn (1900), shows definite resemblances to *Paracænopus filholi* (Osborn). (See Abel 1910 and Roman 1912.) It is also remotely possible that it is related to the genus *Protaceratherium* Abel (1910). *Paracænopus* differs chiefly in having a well developed internal cingulum on the molars. Its premolar metamorphosis commences with P 2/, as in the American forms, but P 3/ is more advanced, whereas P 4/ is much more primitive, than in *Amphicænopus*. *Protaceratherium* resembles *Amphicænopus* in the reduction of the internal cingulum of the molars, but is much more advanced. Unless, however, the contrary is proved, it seems much more probable that the American forms are a separate line of autochthonous development, arising from *Trigonias*.

Amphicænopus platycephalus (Osborn and Wortman) 1894
Pl. XVIII, Osborn, 1898

Aceratherium platycephalum Osborn and Wortman. Osborn and Wortman, 1894.
Aceratherium platycephalum Osborn and Wortman. Osborn, 1898, Pl. XIII and XVIII.
Cænopus platycephalus (Osborn and Wortman). Osborn and Matthew, 1909.
Cænopus platycephalus (Osborn and Wortman). Troxell, 1921 a.

The holotype is a skull, A. M. N. H. No. 542. A. M. N. H. No. 540, consisting of right P 1/–M 3/ is the paratype. Both these specimens, and all other known specimens referred to this species, except A. M. N. H. Nos. 1478 and 12453, are from the Protoceras Beds. I 2–(1)/2, C 0/0, P 4/4–3, M 3/3. I /2 is semiprocumbent. These are hornless rhinoceroses exceeding *Subhyracodon tridactylum* in size, with rather unprogressive premolars. The internal cingulum is complete and quite well developed on the upper premolars. P 1/ is relatively small, and simple in the slight development of its protoloph and metaloph. P 2/ is well advanced. Its protoloph and metaloph are parallel, and are separate until an advanced stage of wear. P 3/ is never molariform. Its hypocone is a conical cusp, distinct from both protocone and metaconule until a fairly advanced stage of wear, when it becomes confluent with the protocone. The principal outlet of the median valley is posterior. P 4/ is variable. In A. M. N. H. No. 540, it resembles P 3/ closely, with the hypocone an independent cusp, but more closely attached to the protocone, making the principal outlet of the median valley the posterior one. In the type, A. M. N. H. No. 542, the deepest outlet of the median valley is internal, on both sides. Right P 4/ has the hypocone attached to the metaconule, though it may well have been separate in the unworn tooth. Left P 4/ is more molariform, and resembles some specimens of *Subhyracodon tridactylum*. There is no internal cingulum, except a rudiment in the valley on M 1/ and M 2/. M 3/ apparently has none in the type, but a nearly complete, although rather faint one in the paratype.

In the original description (Osborn & Wortman, 1894), the type is given as No. 545. Osborn (1898, page 140) gives No. 542 as the type. No. 540 is given as co-type (= paratype) in 1894, and in 1898 on page 140. In the same paper, however (Osborn 1898, page 141 and Plates XIII and XVIII), No. 540 is referred to as the type, and No. 542 as the co-type. This confusion can be cleared up definitely, as the type description is of the skull, No. 542, although, by a misprint, it is called No. 545. The set of right cheek teeth, No. 540, is therefore the paratype.

Osborn (1898) described the lower jaw from A. M. N. H. No. 1444. Its most diagnostic character is the large size of the teeth and the jaw.

Amphicænopus platycephalus ? (Osborn and Wortman)

Aceratherium platycephalum Osborn and Wortman. Osborn, 1898, p. 141, A. M. N. H. No. 1478.

This description is based on A. M. N. H. No. 1478, collected by Mr. J. W. Gidley, in 1896, from the Titanotherium Beds, Sand Creek, Hat Creek Basin, Nebraska. I 1/(3)–2, C 0/0, P 4–3/4–3, M 3/3. The specimen consists of the skull with the lower jaw, with P 2/–M 3/ of both sides, left P /4–M /3 and right M /2 and M /3, with cervicals 2–5, and a metatarsal, and both I 1/'s, right I /1–2, left I /1–3, left P /1–3 and right P /2–M /1, represented by their alveoli. The individual was very old, and the teeth are exceedingly worn, so that most of the pattern is obliterated. The following characters are still apparent. The internal cingula on the upper premolars are complete, but not especially prominent. P 4/ has the hypocone still connected with the protocone (although partly separated from it by a groove, internally), allowing the median valley to escape posteriorly. Both third upper molars retain faint traces of the posterior buttress. The upper molars are without an internal cingulum. There are very small alveoli for the third left lower incisor and the first left lower premolar, but there is no trace of either on the right side.

It is rather probable that a younger specimen would show differences of specific value from *Amphicænopus platycephalus*, but it seems best to allow the new species, if it is one, to be founded on some less nondescript type specimen. A younger specimen would be likely to show a closer approach toward *Trigonias paucidens*. If a new species were named from this specimen, the chief character would have to be its horizon. There are minor morphological differences. It is slightly smaller throughout. The mandible is much shallower under P /2. The lower jaw of *Amphicænopus platycephalus*, A. M. N. H. No. 1444, has a double mental foramen under the lower incisor tusk. In this specimen it is single, under P /1 on the left and anterior to P /2 on the right side. The character of this foramen, however, seems to be very variable and of little or no diagnostic importance. Judging from the characters that are still preserved, this form is noticeably more advanced than *Trigonias paucidens*, in the loss of I 3/ (and I 2/??), in the increase in size of the hypocone of P 4/ and in its closer approach to separation from the protocone.

A. M. N. H. No. 12453, collected by Mr. H. F. Wells in 1905, from the Upper Titanotherium Beds, Cane Creek, South Dakota, a very badly damaged lower jaw, has the same abnormally slender rami as No. 1478. This may turn out to be a good specific character.

Amphicænopus ? simplicidens (Cope) 1891 Fig. 43, Osborn, 1898

Cænopus simplicidens Cope. Cope, 1891.

Aceratherium simplicidens (Cope). Osborn and Wortman, 1894.

Cænopus (= *Subhyracodon*) *simplicidens* (Cope). Osborn and Matthew, 1909.

Cænopus simplicidens Cope (of doubtful validity). Troxell, 1921 a.

The holotype is A .M. N. H. No. 10708, from the Oligocene, Big Badlands, S. D., consisting of the third left upper molar with rather more than half of the second left upper molar attached to it. It is not determinable specifically, nor, with absolute certainty, generically. M 2/ has no internal cingulum, M 3/ has a weak one. It is more probably *Amphicænopus* cf. *platycephalus* than anything else, but might almost equally well be referred to as *Trigonias* cf. *osborni* or to *Trigonias* cf. *paucidens*, and other references might be conceivable. The degree of resemblance certainly does not warrant reducing *Amphicænopus platycephalus* to synonymy. This "species" has only an antiquarian interest and should be dropped from faunal lists.

DISCUSSION

There are several interesting conclusions that can be drawn from the last table. It would appear that the ratios Mtc III/R, and, to a lesser extent, Mts III/T, tend to be

Table V a

	Caenopus mitis Paratype A.M.N.H. 8325 R	L	*Subhyracodon copei* Holotype A.M.N.H. 522 R	L	*Subhyracodon copei* A.M.N.H. 6328 R	L	*Subhyracodon trigonodum* Holotype A.M.N.H. 528 Paratype 529 R	L	*Subhyracodon "trigonodum elium"* Holotype Y.P.M. 12052 R	L	*Subhyracodon occidentale* Neotype U.S.N.M. 114 R	L	*Subhyracodon occidentale* A.M.N.H. 6330 R	L	*Subhyracodon gidleyi* Holotype U.S.N.M. 11337 R	L	*Subhyracodon metalophum* Holotype Y.P.M. 10254 R	L
I^1 - C^1, over all	---	---	48	48	---	---			---	---	---						---	---
A-P diam. I^1	---	---	20.5	18	---	---			23.5	24	---						25	24
Tr. diam. I^1	---	---	9.5	10.5		12.5			10	11	---						11	11
							No. 528											
Crown-length of I^2	---	---	---	---	---	---		7.5	12	13	---						---	---
A-P diam. I^2	---	---	13.5	13.5		17		9	10	13	---						---	---
Tr. diam. I^2	---	---	9.5	9.5		12.5		5.5	7.5	8	---						---	8.5
Crown-length of C^1	---	---	---	---					---	---	---						---	---
A-P diam. C^1	---	---	7.5	5	---	4.5			---	---	---						---	---
Tr. diam. C^1	---	---	6	7	---	7			---	---	---						---	---
Diastema	---	---	38	38	---	34			37	37	---	37 ±					---	35
Length, P^1-M^3	---	---	158.5	158.5	---	---	174	---	---	---	---	182					---	195
Length, P^2-M^3	---	---	145	144	---	---	160.5	163.5	---	---	---	165					183	176.5
Length, P^{1-4}	69.5	---	78.5	78.5	---	---	82.5	---	98	94	85	e 85					---	95
Length, P^{2-4}	58	---	59.5	60	59	---	68.5	69.5	76	73.5	72	87			---	62.8	78	76
Length, M^{1-3}	---	---	84.5	83	---	---	100.5	101.5	---	---	---	100		106.0		---	108	103
Length, P^1	13	---	17	17.5	---	---	17.5	---	20	20	---	e 19			---	---	---	20
Width, P^1	---	---	16.5	18	---	---	18	---	17.5	18	---	---			---	---	---	19.5
Length, P^2	17	---	18.5	20	18	---	20	19.5	23.5	22.5	22.3	20.5			---	19.4	25	23
Width, P^2	23	---	24.5	25	23	--	--	22.5	26	28	---	26			---	25.0	30	---
Length, P^3	19	---	20.5	20.5	19	---	23	22	26	26	21.5	22.3			---	21.0	26	28
Width, P^3	28	---	29.5	29	27.5	---	31	31	33.5	33	---	34.1			---	27.3	36	35.5
Length, P^4	20	20	20.5	21.5	---	---	22.5	23	28	26.5	24.3	25.5		27.0	22	22.6	25.5	27
Width, P^4	33.5	33.5	32	32	---	---	33.5	32	37	37	---	37		38.5	31.8	32	40	39
Length, M^1	27	27	26	25.5	26.5	27	29	28.6	33	33	31	30.5		33.0	29	28.3	34	34
Width, M^1	33	33	32.5	33	31	31.5	36	36.5	37	37.5	---	38.8		---	---	34.0	39.5	39.5
Length, M^2	---	30.5	29	28.5	29.5	---	34	34	37	38	36	34.6		35.7	31	32	36	35
Width, M^2	---	38	35.5	36	e 35	---	38.5	38.5	39.5	40	---	41.5		42.0	36.5	36	39.5	41
Length, M^3	---	---	29.5	29.5	e 33	---	31.5	32	---	---	---	34.5		38.0	---	---	38	35
Width, M^3	---	---	33.5	34	---	---	38.5	39	---	---	---	40.5		39.0	---	---	37	39.5
							No. 529											
Tip nasals to oc. crest	---	---	408.5	402			451	434.5	---	---	----						---	---
Pmx to oc. condyle	---	---	409.5	406.5			---	---	---	---	---						---	e 461
Greatest width across zygomas	---	---	198				198.5		---	--	----						---	---
Depth incision ant. nares	---	---	77.5	73			e 80.5	65.5	67	87	---						---	---
Height occiput above condyle	---	---	116	111.5			115.5	112	---	-	---						150	157
Least width bet. R and L. P^2's	---	---	30.6				41		---	-	24.8						---	---
Least width bet. R and L. M^3's	---	---	52.5				59		---	-	48.4						---	---

Table V b

	Subhyracodon metalophum A.M.N.H. 1123		Subhyracodon tridactylum Holotype A.M.N.H. 538		Subhyracodon proavitum Holotype P.U. 10985		Diceratherium avum Holotype Y.P.M. 10251		Diceratherium lobatum Holotype Y.P.M. 12487		Amphicaenopus platycephalus Holotype 542		Amphicaenopus platycephalus Paratype A.M.N.H. 540	Amphicaenopus platycephalus ? A.M.N.H. 1478		Amphicaenopus ? simplicidens Holotype A.M.N.H. 10708
	R	L	R	L	R	L	R	L	R	L	R	L	R	R	L	L
$I^1 - C^1$, over all	----		58.5	---	---	---	---	---	---	---	---			---	---	
A-P diam. I^1	v22	---	28	29	---	---	---	---	20.5	20	---	---		21.5	21.5	
Tr. diam. I^1	v11.5	---	13.5	12	---	---	---	---	8.5	8.5	---	---		9	9	
Crown-length I^2	----		12	13	---	---	-----		9.5	11	---	---		---	---	
A-P diam. I^2	v18.5	---	9.5	9.5	---	---	----		13	14	---	---		---	---	
Tr. diam. I^2	v9.0	---	8	8.5	---	---	----		7	7	---	---		---	---	
Crown-length C^1	---	---	---	---	---	---	----				---	---		---	---	
A-P diam. C^1	---	---	---	---	---	---	---	---			---	---		---	---	
Tr. diam. C^1	----		---	---	---	---	---	---			---	---		---	---	
Diastema	44.0	---	51.5	60	---	---	---	---	57	51	---	---		107	---	
Length, P^1-M^3		198.5	215	221	---	---	---	---	---	---	236	238	241	234	---	
Length, P^2-M^3	176	176	t198		---	---	---	---	---	---	217	226	220.5	215.5	216	
Length, P^{1-4}		94	t102.5	t107.5	97	98.7	109	111	118	116	94	99.5	118	118.5	---	
Length, P^{2-4}	74.5	73.5	t83.5	t88	78.8	75.8	86	90	83	83	79	88	84.5	87.5	85	
Length, M^{1-3}	105.0	105	t118		---	---	---	---	---	---	138.5	141	138	129	131.5	
Length, P^1	---	21.5	22	25	21.0	21.0	23	25	---	25	---	---	23.5	---	---	
Width, P^1	---	21.0	21	21	20.8	22.4	23.5	21	---	21	---	---	17	---	---	
Length, P^2	22.0	22.0	t24	t28	24.5	24.8	28.5	28	°25	28	---	23.5	23.5	28	26	
Width, P^2	28.5	30.0	e34	---	31.5	32	33	31	33	33	---	36.5	29	33	34	
Length, P^3	26.0	25.0	t29	t29	24.4	25.4	28	30	33	33.5	27.5	27.5	27	30	29	
Width, P^3	37.5	37.0	---	---	37.3	39.0	39.5	39	45	45	---	41.5	40.5	42.5	41	
Length, P^4	25.5	25.5	t31	t31	27.0	27.0	d33.5	d34	34	33.5	33	33	33	31	30	
Width, P^4	40.0	40.5	---	---	43.4	43	d37	---	50	50	49	48	48.5	48	47.5	
ngth, M^1	32.5	34	t37	t38	35.4	32.7	38	37	---	45.5	45	44.5	41	37.6	38	
Width, M^1	40.0	39.0	---	---	---	44.5	44	43	.	54	54.5	53	53	51.5	---	
Length, M^2	36.0	36.0	t45	---	38.2	37.5	--	40	--	---	45	47.5	48.5	48	46	
Width, M^2	44.0	44.0	---	---	---	47	48	43	---	53	56	58	58.5	58.5	57	c50
Length, M^3	35.0	35.0	41.5	---	---	---	---	---			46	50	48	47.5	48	42.5
Width, M^3	40.0	40.0	---	---	---	---	---	---			57	56.5	53	57.5	57	47.0
Tip nasals to oc. crest	----		e510	---	496	492	---	---			---	62.5.		---	---	
Pmx. to oc. condyle	468	---	e592	---	---	---	---	---			---	---				
Greatest width across zygomas	----				281		---	---			c360	---		293		
Depth incision ant. nares	----		108	108	105	108	---	---			125	118.5		---	---	
Height occiput above condyle	----		178	---	---	153	---	---			—	141.5+		158 +	162.5+	
Least width bet. R. and L. P^2's	e35		---		------		---	---			55					
Least width bet. R. and L. M^3's	63.0		---		------		---	---			83			68		

d, deciduous
e, estimated
t, measured along ectoloph
v, alveoli only

Table VI

	Caenopus mitis Holotype A.M.N.H. 6325 R	L	Caenopus dakotensis Holotype A.M.N.H. 1110 R	L	Subhyracodon trigonodum A.M.N.H. 529 R	L	Subhyracodon "trigonodum ellum" Holotype Y.P.M. 12052 R	L	Subhyracodon tridactylum Holotype A.M.N.H. 538 R	L	Amphicaenopus platycephalus A.M.N.H. 1444 R	L	Amphicaenopus platycephalus? A.M.N.H. 1478 R	L	Amphicaenop platycephal? A.M.N.H. 12453 R	L
Tip I_2 to back of I_3	---	---	---	---	---	---	---	---			---	---	---	---		
Crown length of I_1	---	---	---	---	---	---	---	---	9.0	---	---	---	---	---		
A-P diam. I_1 at root	---	---	---	---	---	---	---	---	7.5	---	6	6	6	6		
Tr. diam. I_1 at root	---	---	---	---	6	5.5	---	---	7.0	---	6	6	6	4.5		
A-P diam. I_2	9	9	9	---	---	14.5	----		22.0	19.0	---	32.5	24.5	27.5		
Tr. diam. I_2	---	10 +	13	---	---	21	----		280	30.0	---	38.5	19.5	15.5		
Crown length I_3 from root	---	---	---	---			----			----	---	---	---	---		
A-P diam. I_3 at root	---	---	---	---			----			----	---	---	---	6		
Tr. diam. I_3 at root	---	---	---	---			----			----	---	---	---	6		
Diastema	---	---	e22	---	[illegible]	18	----		53.0	66.5	---	73	78	58.5		
$P_1 - M_3$	---	---	---	---			--	--		----	---	---	---	22.0		
$P_2 - M_3$	---	---	124	e127.5	170	---	-	-	205.5	205.5	---	221	213.5	212.5	226	224
P_{1-4}	---	---	---	---			-	---		----	---	---	---	91		
P_{2-4}	---	57	48.5	e50	86	---	---	--	85.0	89.0	---	82	90	82.5		
M_{1-3}	87	---	75.5	77	105.5	---	---	---	122.0	---	---	142	132.5	132		140
P_1, length	---	---	absent		absent		----			----	---	---	---	---		
P_1, width	---	---	aboent		absent		----			----	---	---	---	---		
P_2, length	---	14.5	13.5	---	21.5	---	----		26.0	25.0	---	19.5	---	---		
P_2, width	---	8	---	---	12.5	---	----		16.5	---	---	14.5	---	---		
P_3, length	---	19.5	17.0	---	23.5	---	----		31		---	31	---	---		
P_3, width	---	11	13.5	---	16	---	----		---		---	24.5	---	---		
P_4, length	---	18	16.5	18.0	24	---	---	28	31		---	32	---	32.5		
P_4, width	---	12	14.5	14.5	18	---	---	20.5	---		---	30.5	---	27		
M_1, length	25	26	20.0	21.5	28.5	---	33.5	33.5	35.		---	40.5	---	40		
M_1, width	e19	17.5	15.5	---	27	---	21	21	---		---	33	---	32.5		
M_2, length	e26	---	27.5	27.0	37	---	38	36.5	42		---	50	46.5	46		
M_2, width	e19	--	16.5	16.5	23	---	[illegible]	22.5	---		---	36	33	34		
M_3, length	31	---	27	27	40.5	---	---	---	44		---	55.5	51.5	54.5		55.5
M_3, width	e19	---	16	15.5	22	---	---	---	---		---	33.5	32	33		33.[illegible]
Symphysis to angle	---	---	252.5	271.5	331	---	- -	---	---	452	---	529	513	507		
Coronoid above angle	---	---	148 +	140.5 +	180	---	---	170 +	261		---	---	252.5	249		
Length of symphysis	43	---	48.5		81		----		103		---	125	98.5		100	
Depth ramus below P_2	---	40	38.5	---	45	---	----		70	---	---	84	57	60	---	53
Depth ramus below M_2	---	---	48.5	15.6	62	---	53.5	54	e74.0		---	e93	84	86	63	55

Table VII

	Humerus (H)	Radius (R)	Metacarpal III (Mtc III)	R/H (H=1)	Mtc.III/H H=1	Mtc.III/R R=1	Femur (F)	Tibia (T)	Metatarsal III (Mts. III)	T/F (F=1)	MtsIII/F F=1	MtsIII/T T=1
Opsic. (Ceratotherium) simum A.M.N.H. #51858	495	417	187	.85	.38	.45	523	397	175	.76	.34	.44
Opsiceros bicornis A.M.N.H. #27757	475	414	190	.87	.40	.46	495	376	172	.76	.35	.46
Didermoceros sumatrensis A.M.N.H. #54763	412	313	159	.76	.39	.51	446	326	145	.73	.33	.44
Subhyracodon tridactylum A.M.N.H. #538	363	289	145	.79	.40	.50	423	353	130	.83	.31	.37
Caenopus mitis, perhaps mixed with S. copei, A.M.N.H. #6325		204					291	234		.80		
Trigonias osborni C.M. # 95	306	262	126.5	.86	.41	.48						
Teleoceras fossiger[x]	305[e]	238	114	.78	.37	.48	408	233	105	.57	.26	.45
Metamynodon planifrons[x]	393	320	153	.81	.39	.48	480	280	118	.58	.25	.42
(After Peterson) Menoceras cooki	250	250	138	1.00	.55	.55	323	275	125	.85	.39	.45
Hyracodon apertum P.U. # 11414	227	218	123	.96	.54	.56	260	.230	118	.88	.45	.51
Prothyracodon? obliquidens? C.M. # 2942	140	146	72.5	1.04	.52	.49						
Triplopus cubitalis A.M.N.H. # 5095	112	145	70	1.29	.62	.48						
Hyrachus eximius[x]	197	197	93	1.00	.47	.47	254	243	110	.96	.43	.45
Hyrachus affinis gracilis Y.P.M. # 11173		154	79			.51	154		83		.54	
Hyrachus, from Huerfano A.M.N.H. # 17435	198.	175.	93.	.88	.47	.53	281	235		.84		
Eohippus sp.[x]	121	110	64	.91	.53	.58	162	162	84	1.00	.51	.51
Euprotogonia puercensis[x]							105	107	45	1.02	.43	.42

x, after Gregory
e, estimated

quite stable in the Rhinocerotoidea. The great divergence of *Triplopus* in R/H from all other rhinoceroses, even the most highly cursorial, is an evidence of its remarkably high cursorial specialization, which seems even more out of place on account of its very early age. The two living African rhinoceroses are seen to be very close together, throughout. This is probably due to the combination of rather close relationship and generally similar habitus. The striking parallelism between *Teleoceras* and *Metamynodon,* and between *Menoceras, Hyracodon,* and *Hyrachyus,* may be regarded as due solely to convergence in members of the same general group. The first case represents a semi-aquatic, hippopotamus-like development; whereas the second represents a fairly high degree of cursorial adaptation. Various other deductions of a less striking character could be drawn.

The new genus, *Eotrigonias,* throws the first definite light on the Eocene history of the true rhinoceroses. Study of the genus *Trigonias* shows the close resemblance of *Trigonias osborni* to *Eotrigonias rhinocerinus* leading, in the other direction, through *Trigonias paucidens* to the *Amphicænopus* line. The trace of a posterior buttress on M3/ in most specimens of *Trigonias osborni,* as well as its sporadic occurrence in other Oligocene forms, is of considerable interest as showing a retention of, or reversion toward, the primitive condition.

The generic names, *Trigonias, Cænopus* and *Diceratherium* as generally used in the past, represent a horizontal classification and not a vertical, or truly genetic one. *Trigonias* is "multiserial," and *Cænopus* and probably, *Diceratherium* are "polygenetic"; but the American Eocene and Oligocene Rhinocerotidæ as a whole are only multiserial. There is no evidence whatever that they are polygenetic (See Miller, 1923, for definitions of these terms). For this reason, the "*Cænopus*" group is split into three genera, and the splitting off of *Menoceras* from *Diceratherium* is tentatively accepted.

Osborn's division (1898) of the American Oligocene Rhinocerotidæ into two series, largely on the basis of the position of the premolar hypocone, is in part artificial, since this character is chiefly indicative of the stage of evolution. His series "II" is, in all probability, a real one, but his series "I" is composite and artificial. Series "II," the *Subhyracodon copei-Diceratherium armatum* line, has gradually been confirmed in increasing detail.

Osborn's statement (1898) of the methods of metamorphosis of the upper premolars in the Oligocene rhinoceroses can now be restated more clearly and accurately, and in greater detail. (It will be noted that the method differs in almost every respect from that followed by the horses.) The metamorphosis of the upper premolars in the true rhinoceroses, hyracodonts and hyrachyids takes place as follows:

1. The protoloph, consisting of the protocone and protoconule, is the main transverse crest, the metaconule being a minor crest abutting on the protocone. *Hyrachyus, Prothyracodon.*

2. The protocone elongates antero-posteriorly, and the hypocone commences to split off from it. *Eotrigonias, Hyracodon petersoni, Trigonias osborni.* In both these stages, the median valley opens posteriorly.

3 a. The hypocone is, for a time, a separate cusp, conical in *Trigonias gregoryi, Amphicænopus platycephalus,* and elongate in *Metahyrachyus bicornutus.*

3 b. The hypocone unites with the metaconule before separating from the protocone, giving an enclosed basin. *Triplopus ?* (cf. *Lophialetes*), *Hyracodon arcidens, Leptaceratherium trigonodum, Subhyracodon occidentale, Colonoceras agrestis.*

(*Cænopus mitis* is already so progressive, that the question which course its ancestors took must be left open, but, judging from P 3/, it followed 3 b. Osborn's putting this species in "I" is apparently based on the assignment of a specimen of *S. copei* to this species as paratype.

3 x. P 2/ is most progressive, *Trigonias, Amphicænopus, Subhyracodon, Hyracodon petersoni.*

3 y. P 4/ is most progressive. *Hyrachyidæ, Amynodontidæ, Cænopus mitis,* most European true rhinoceroses, *Hyracodon nebraskensis, H. apertus.*

4. P 2/–P 4/ have all become molariform, with the protoloph and metaloph separate and parallel. *H. leidyanus* and the Miocene to recent rhinoceroses.

There does not seem to be any reason to attach profound significance to these differences in the exact order of appearance of equivalent stages in different lines. The hereditary material of these forms must have been fundamentally similar; it is entirely to be expected that the same characters should appear in the various lines, but in different order.

The method of metamorphosis of the upper molars in the Amynodontidæ is uncertain, as they are already well advanced when they first appear. It seems rather likely that the metaloph is developed from the metaconule only, and that no hypocone ever developed, giving still another mode.

Metamorphosis of the lower premolars takes place as follows in the Hyrachyidæ, Triplopodinæ, and Hyracodontinæ:

1. The hypoconid is a simple antero-posterior ridge, well below the level of the trigonid.

2. The entoconid appears as a separate, low, conical cusp.

3. The entoconid elongates transversely, reaching the base of the hypoconid, but not attaining its height.

4. The hypoconid and entoconid fuse into a continuous, asymmetrical crescent, as in the molars.

Judging from the condition in some specimens of *Trigonias osborni,* the earliest true rhinoceros in which the lower premolars are known, the Rhinocerotidæ follow a similar course, except that instead of stage 3, the hypoconid throws off a hook mediad which fuses with the conical entoconid. The method followed by the Amynodontidæ is unknown.

Peterson (1920) and Troxell (1922 a) have endorsed Marsh's suggestion (1877) that the horned rhinoceroses of the Miocene were descended from the horned Eocene forms (*Colonoceras* and *Metahyrachyus*). This seems highly improbable. The horns are rather too far posterior on the nasals to give rise to the condition in *Menoceras.* But a more important objection is the great improbability that the true rhinoceroses are polygenetic, still more that any true rhinoceros could be derived from a Bridger hyrachyid, especially in view of the degree of advancement of the genus *Eotrigonias.* The ancestry of *Diceratherium* (as restricted by Troxell) seems too definitely established to make it necessary to consider this suggestion as applied to it. *Metahyrachyus bicornutus* seems clearly worthy of generic distinction, and shows, as Troxell has pointed out, a number of resemblances to true rhinoceroses. The horn cores are so far posterior, however, that it seems highly unlikely that it could have been ancestral to any other known rhinoceros. Comparison with *Eotrigonias* indicates that it is simply the most progressive of the hyrachyids, paralleling the true rhinoceroses in some respects.

The terms "Diceratheriinæ" and "Aceratheriinæ," when used in their customary complimentary sense for the horned and hornless American forms, are useless and misleading, and should be abandoned. If they are to be replaced at all, which seems of doubtful utility in the present state of our knowledge, they should be replaced by names indicating the separate lines of development.

Phyletic trees are extremely useful, if regarded as tentative summaries of contemporary knowledge. It is much easier to deal intelligently with a group of related forms if they can be visualized as a unified whole, in their probable or possible relations to each other, rather than as a series of isolated items in a card catalogue. And certainly, in principle at least, the phylogenetic viewpoint is closer to the truth. The "family tree" (fig. 1) is given as my interpretation of the most probable relationships of the forms discussed in this paper and of a few others. The assumed lines of descent are based primarily on tooth structure, secondarily on the structure of the limbs. The subdivision of the old "*Cænopus*" agglomeration also coincides with the bodily size of the different groups, giving series of small, intermediate, and very large forms.

In regard to relative level of different forms in the Titanotherium Beds, Dr. Matthew states (verbal communication) that it does not seem possible to correlate, even between finds in different parts of the same general area. He believes that these deposits were made by streams which were constantly shifting their beds, and that the top of the beds in one locality may be equivalent to their bottom a few miles away. However, in the chart, forms from the Titanotherium Beds are placed in the level given by the collector, whenever it was recorded.

SUMMARY

1. During the lower Eocene, the rhinoceroses apparently split into four main lines, the little-modified descendants of the primitive type, the Hyrachyidæ; the Amynodontidæ; the Hyracodontidæ, which shortly split into two divergent lines, the Hyracodontinæ and the Triplopodinæ; and the Rhinocerotidæ.

2. The Hyrachyidæ kept most of their primitive heritage. The manus was always tetradactyl. No teeth were lost, except P /1. The premolars never became molariform. The cusps of the upper molars never fully lost their separate identity by fusion into lophs.

3. The Amynodontidæ increased progressively in bulk. The tetradactyl manus was retained, and horns were never developed. The canines and molars increased enormously in size, whereas the incisors and premolars were reduced in number and size.

4. The Hyracodontidæ developed cursorially, with tridactyl manus. The Hyracodontinæ achieved moderate cursorial specialization and the premolars became progressively molariform. The Triplopodinæ developed aberrantly, achieving great cursorial specialization associated with primitive or aberrant premolar characters.

5. The Rhinocerotidæ, appearing in the Middle Eocene of America, developed, first as tetradactyl, then as tridactyl forms, with I 1/ and I /2 greatly enlarged, and with progressive reduction of the other front teeth. The posterior buttress of M 3/ was soon lost. In the Oligocene of North America, there were three main lines of evolution, the small forms such as *Cænopus mitis* with P 2/ and P 4/ molariform; the larger forms such as *Subhyracodon occidentale,* in which metamorphosis commenced with P 2/, and the still larger series including *Trigonias* and *Amphicænopus platycephalus,* in which the premolar metamorphosis was much retarded.

6. Premolar metamorphosis in the rhinoceroses seems to occur as follows. In the upper teeth, the protocone elongates antero-posteriorly, and develops an incipient separation across the middle, marking off the posterior half as the hypocone. Either at this stage, or else after the separation is complete, the metaconule becomes attached to the hypocone, forming a complete metaloph. As a result, the median valley opens internally instead of posteriorly. There is a gradual backward rotation of the metaloph, until it becomes approximately parallel with the protoloph. This is accomplished partly by backward migration of the hypocone, partly by shifting the outer attachment of the metaconule anteriorly.

Metamorphosis of the lower premolars takes place as follows in the Hyrachyidæ, Triplopodinæ, and Hyracodontinæ:

1. The hypoconid is a single, antero-posterior ridge, well below the level of the trigonid.
2. The entoconid appears as a separate, low, conical cusp.
3. The entoconid elongates transversely, reaching the base of the hypoconid, but not attaining its height.
4. The hypoconid and entoconid fuse into a continuous, asymmetrical crescent, as in the molars.

Judging from the meagre evidence, the Rhinocerotidæ follow a generally similar course, except that instead of stage 3, the hypoconid sends of a hook mediad, which fuses with the conical entoconid. The method followed by the Amynodontidæ is unknown.

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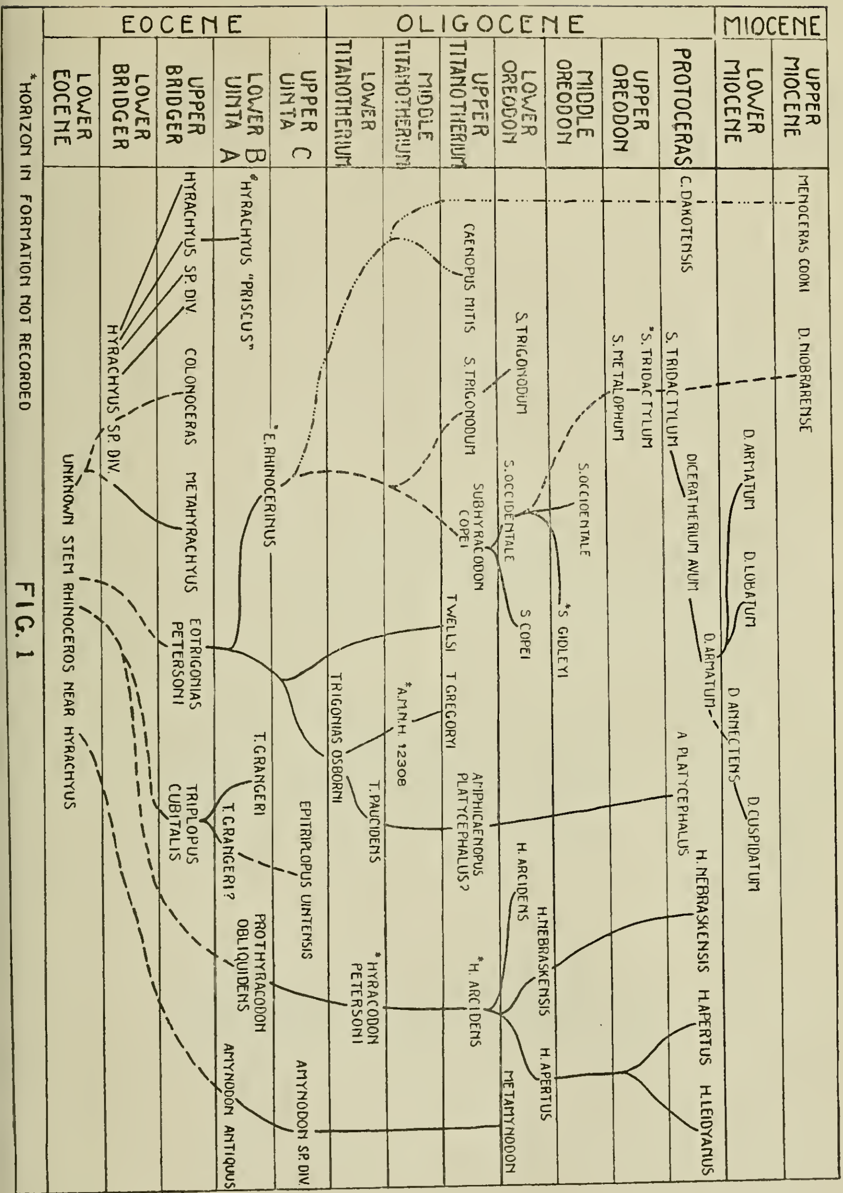
THE END

Explanation of Figures

EXPLANATION OF
PLATE 1

Fig. 1. Phylogenetic Chart. Page 81.



*HORIZON IN FORMATION NOT RECORDED

FIG. 1

EXPLANATION OF

PLATE 2

FIGURE

2. *Triplopus cubitalis*, type, A. M. N. H. No. 5095, right manus, x 1.

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3. *Triplopus cubitalis*, type, A. M. N. H. No. 5095, L P 1/–M 3/ (M 2–3/ reversed from right side), x 1.
4. *Triplopus cubitalis ?* A. M. N. H. No. 2344, R C /1–M /3, x 1.
5. *Triplopus grangeri*, type, A. M. N. H. No. 1972, R M /1–3, x 1.
6. *Triplopus grangeri*, type, A. M. N. H. No. 1972, L P 4/–M 3/, x 1.
7. *Triplopus grangeri ?*, C. M. No. 2336, L P 3/–M 3/, x 1.

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8. *Hyracodon nebraskensis*, A. M. N. H. No. 12460 L I /1–C /1, x 1.

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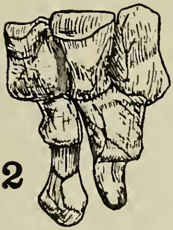

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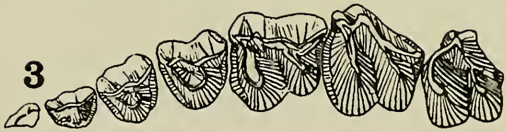

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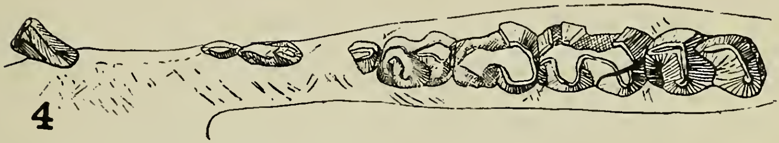

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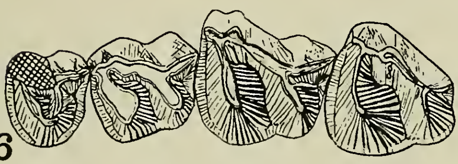

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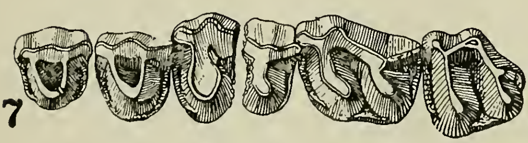

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EXPLANATION OF

PLATE 3

FIGURE

9. *Epitriplopus uintensis,* type, C. M. No. 3007 a,
L P 1–3/,–d P 4/, M 1–3/, x 1.

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10. *Prothyracodon obliquidens,* A. M. N. H. No. 1971,
R P 2/ – M 3/, x 1.

11. *Prothyracodon obliquidens,* A. M. N. H. No. 1971.
L P /1 – M /3, x 1.

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12. Young *Hyracodon* sp., C. M. No. 318,
L d P /3 – M /1, x 1.

13. Young *Hyracodon* sp., C. M. No. 3581,
L d P /4 – M /1, x 1.

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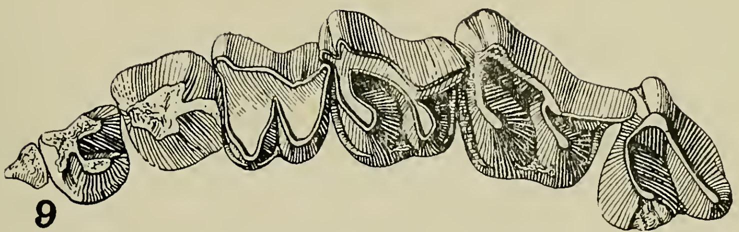

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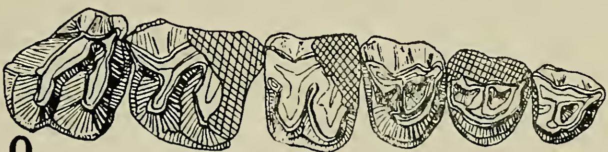

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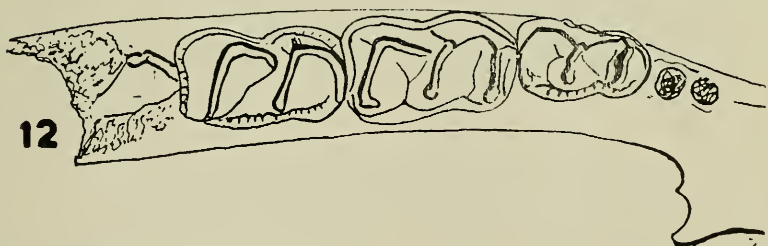

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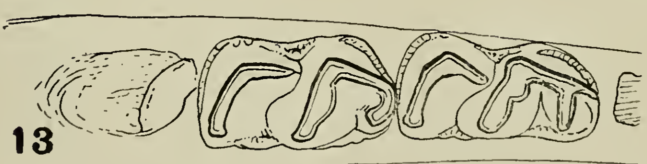

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EXPLANATION OF

PLATE 4

FIGURE

14. *Triplopus grangeri ?*, C. M. No. 3110,
R P 3/ – M 2/, x 1.
15. *Triplopus grangeri ?*, C. M. No. 3110,
L P /2 – M /3, x 1.
Page 17
16. *Eotrigonias petersoni*, type, A. M. N. H. No. 2341,
L P 4/ – M 3/, x 1.
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17. *Eotrigonias rhinocerinus*, type, Y. P. M. No. 13331,
L P 2/ – M 3/, x 1.
18. *Eotrigonias rhinocerinus*, type, Y. P. M. No. 13331,
R M 3/, x 1.
19. *Eotrigonias rhinocerinus*, type, Y. P. M. No. 13331,
R P /4 – M /3, x 1.
Page 32


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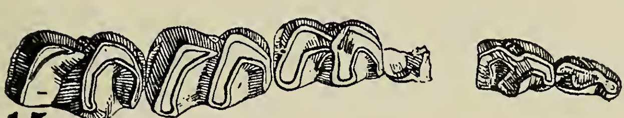
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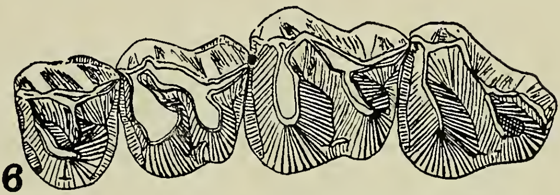
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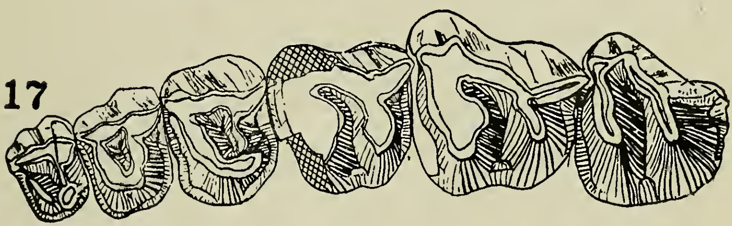

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EXPLANATION OF PLATE 5

FIGURE

20. *Trigonias osborni*, type, U. S. N. M. No. 3924, L P 1–3/, x ½.

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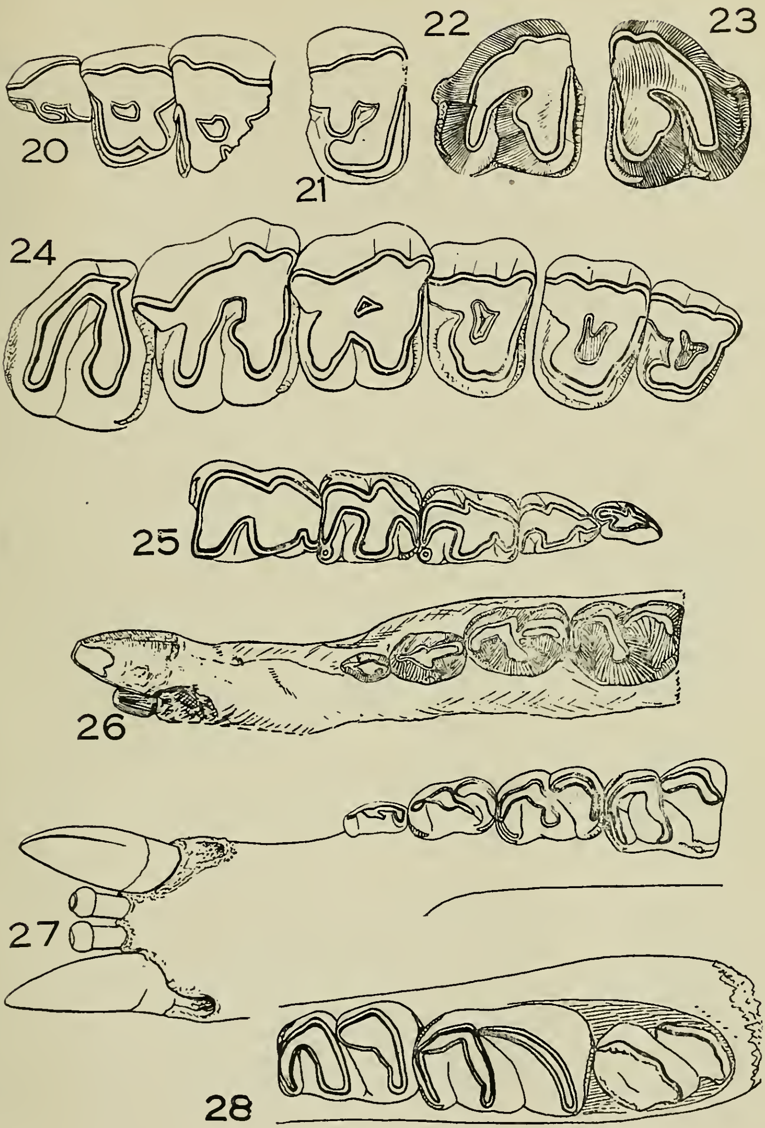
21. *Trigonias osborni*, type, U. S. N. M. No. 3924, R P 3/, x ½.
22. *Trigonias osborni*, C. M. No. 95, R M 3/, x ½.
23. *Trigonias osborni*, C. M. No. 95, L M 3/, x ½.
24. *Trigonias osborni*, C. M. No. 98, R P 2/ – M 3/, x ½.
25. *Trigonias osborni*, U. S. N. M. No. 4815, L P /1 – M /1, x ½.
26. *Trigonias osborni*, A. M. N. H. No. 9792, R I /1 – P /4, x ½.
27. *Trigonias osborni*, C. M. No. 97, lower incisors and R P /1–4, x ½.
28. *Trigonias osborni*, C. M. No. 97, R M /1-3, x ½.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EXPLANATION OF

PLATE 6

FIGURE

29. *Subhyracodon gidleyi,* type, U. S. N. M. No. 11337,
R P /2, x ½.
30. *Subhyracodon gidleyi,* type, U. S. N. M. No. 11337,
L P /3, x ½.
31. *Subhyracodon gidleyi,* type, U. S. N. M. No. 11337,
L P 2/ – M 3/, x ½.

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32. *Trigonias wellsi,* type, A. M. N. H. No. 13226 (1),
L I 1/, I 3/, d C 1/, C 1/, x ½.
33. *Trigonias wellsi,* type, A. M. N. H. No. 13226 (1),
L P 1–4/, x ½.

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35. *Trigonias paucidens,* type, A. M. N. H. No. 11865,
R-I 2–3/, L I 3/, x ½.

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38. *Trigonias gregoryi ?,* A. M. N. H. No. 13226 b,
R P /1-3, d P /4, x ½.

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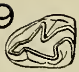

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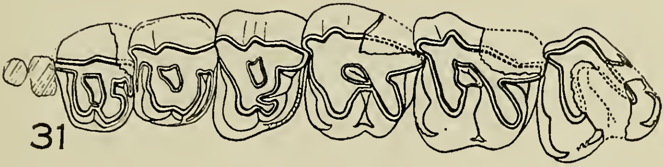

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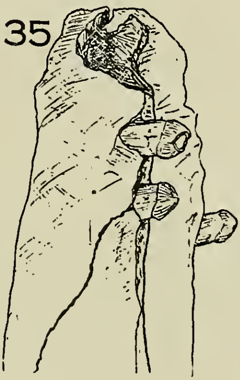

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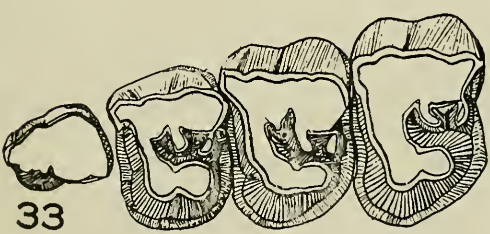

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EXPLANATION OF

PLATE 7

FIGURE

34. *Trigonias wellsi,* type, A. M. N. H. No. 13226 (1),
L M 1–/, x ½.

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36. *Trigonias paucidens,* type, A. M. N. H. No. 11865,
R P 1–4/, x ½.

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37. *Trigonias* sp., A. M. N. H. No. 12308, L P 4/, x ½.
39. *Trigonias gregoryi,* type, A. M. N. H. No. 13226 a,
L P 1–4, x ½.
40. *Trigonias gregoryi,* type, A. M. N. H. No. 13226 a,
L M 1–3/, x ½.

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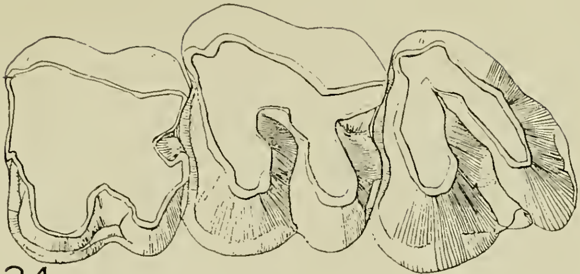

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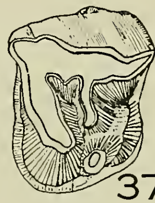

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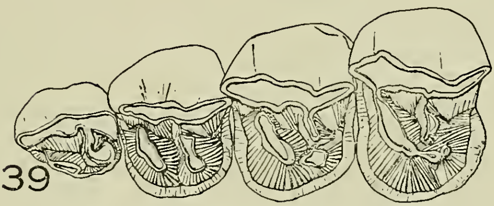

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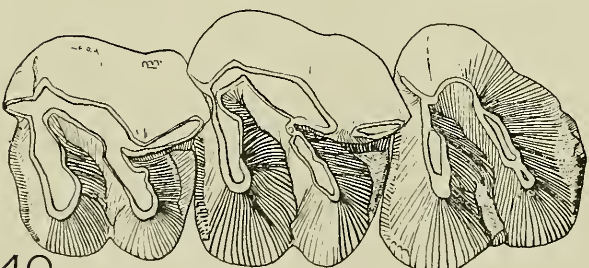

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